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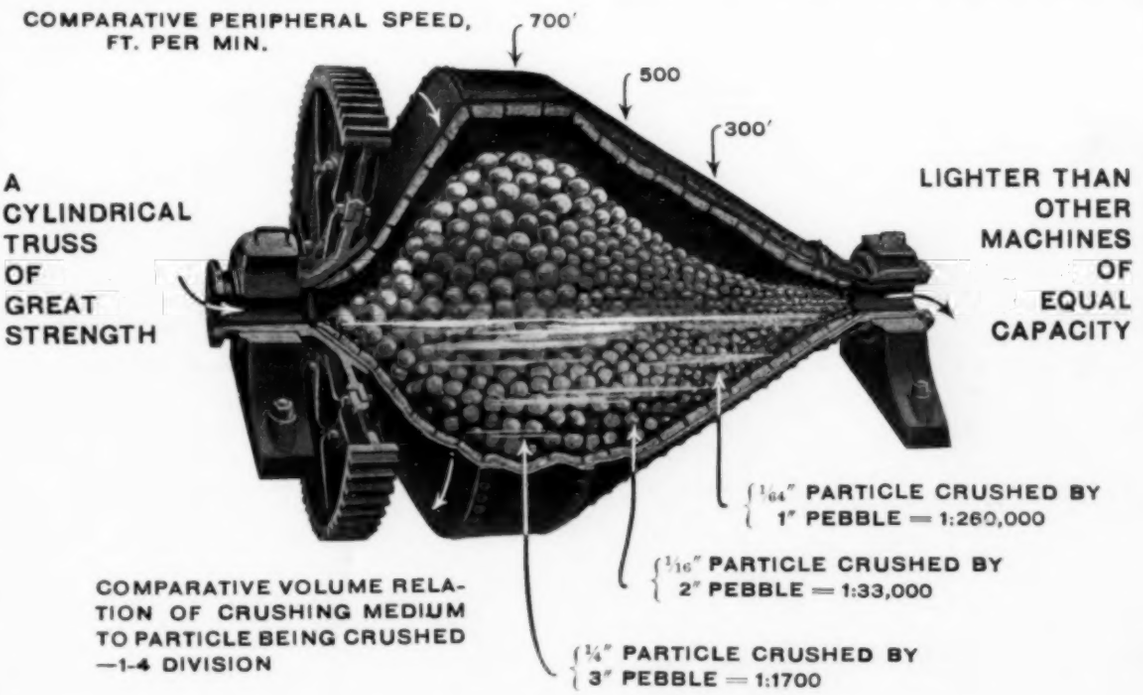
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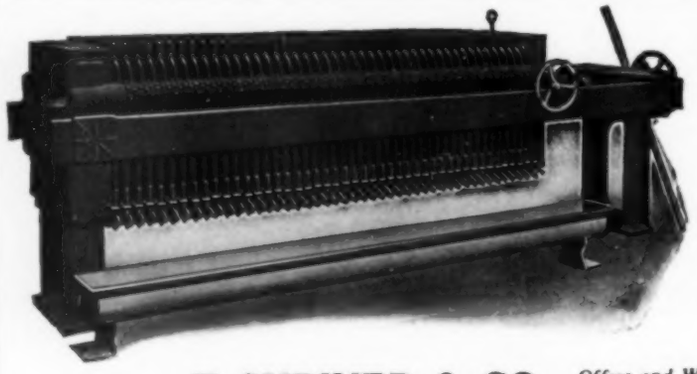

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The Laws of Crushing

Will someone with a mathematical mind and a practical knowledge of the art of crushing rock, volunteer to sacrifice himself in the interests of science by attempting a satisfactory solution of the vexed question as to whether the laws of Rittinger or Kick apply in the work of crushing? Is the work of crushing proportional, respectively, to the reduction in diameter of the particles, or does it vary as the volumes and weights of these bodies?

There are staunch advocates of both of these contentions. Stadler, of South Africa, is firm in the support of Kick's law; and recent investigators at McGill University in Canada are said to have arrived at similar conclusions. More recently Taggart, of Yale, has taken the same stand. On the other side, Del Mar and Gates and Robert H. Richards have publicly supported the law of Rittinger, which Stadler says is a myth resulting from a misinterpretation of Rittinger's words.

This leaves us in suspense. From Rittinger and Kick on down to the latest convert, the various advocates have commanded respect for their knowledge and ability. And yet on this point they are in disagreement and have divided an otherwise united following into two camps. The way is open for someone to harmonize the two factions. In the meantime the mechanical efficiencies of crushing machines and the power consumed in the work of crushing will remain moot questions until agreement is reached as to the proper method of calculation.

The Statistics of Pig Iron Production

Of the 30,966,301 gross tons of pig iron produced in the United States in 1913, 16,738,952 tons, or 54 per cent., was delivered in molten condition, according to the official statistics issued the middle of February. The quantity of iron other than Bessemer and basic disposed of in molten condition is negligible, while the tonnage of Bessemer and basic produced amounted to 23,814,313 tons, of which the molten iron reported is 70.3 per cent. This indicates a very large employment indeed of direct furnace metal, since owing to the exigencies of Sundays and holidays, as well as blast furnaces running ahead of their attendant steel plants, it is necessary to cast considerable pig iron at plants which regularly use direct metal. It is probably safe to conclude that between 80 and 85 per cent. of the total steel production of the country is made at plants which regularly use the direct metal process, the remaining steel being made at detached steel works which use cold pig, usually purchased in the open market.

The segregation of pig iron into the forms in which cast or delivered commenced only with the year 1912,

so that comparative statistics are lacking to show the growth of the direct metal process, but it is well known that it was not used in plants which produced as much as half the total steel production. The statistics returned are as follows, "chill cast" meaning simply iron which was cast in loose chills, set by hand, instead of in chills carried mechanically:

	1912	1913
Molten condition	16,466,722	16,738,952
Sand cast	6,309,495	6,689,680
Machine cast	6,214,121	6,522,075
Chill cast	6,726,017	1,000,172
Direct castings	10,582	15,422
Total	29,726,937	30,966,301

An improvement is introduced in the 1913 statistics, by the segregation of merchant pig iron. The tonnage made for sale is given at 9,734,238 tons, the quantity made for the use of the producers being 21,232,063 tons. The latter item is made up almost exclusively of pig iron made by the regular steel interests, and includes almost all of the 16,738,952 tons reported as delivered molten.

The production of pig iron in 1913 established a new record, passing the 1912 output by 1,239,364 tons, or 4.2 per cent. The year 1906 stands out as the last year during which there was full production throughout the year, the 25,307,191 tons produced in that year representing substantially the full capacity of the furnaces in existence. In 1913 there was not full employment of the existing furnaces, yet there was a gain over 1906 of between 22 and 23 per cent. in the tonnage output. This, however, was quite a moderate gain for pig iron in seven years, seeing that in the past production has usually doubled about once in ten years. However, the 1913 production was nearly double that of 1901, and as much more than double the output in any year previous to 1901. The present capacity may be taken as between 34,000,000 and 35,000,000 tons, or 3,000,000 to 4,000,000 tons in excess of the actual output last year. This estimate of capacity is based upon the possibilities of actual commercial performance, with raw materials and finished products selling at moderate, but not ordinarily profitless prices. The physical capacity, including furnaces which can operate profitably only when there is a very wide margin, is perhaps several million tons greater.

Improvements in Copper Converting

Basic-lined copper converters have practically superseded those with acid lining, with attendant great increase in the duty per lining. Practice has changed radically, from providing a lining which was intended to be consumed, to one presumed to be chemically inert under the conditions existing in the converting process. The present tendency is to make every effort to protect the lining from destruction and to supply from without the necessary fluxing ingredients to convert the matte to blister copper.

In this connection the recently patented idea of Messrs. A. E. Wheeler and M. W. Krejci, of Great Falls, Mont., bids fair to have a wide influence on the metallurgy of copper. They coat the basic lining of a converter with a layer of magnetite so that no portion of the lining is exposed, and is thus protected from destruction. This protective layer is formed synthetically when the converter is first placed in commission and its thickness is thereafter controlled by attention to details of operation. The principle involved is that the blowing of matte with a deficiency of silica results in the formation of magnetite.

When a converter is operated in accordance with the idea of Wheeler and Krejci, its basic lining receives a monolithic coating that prevents mechanical or chemical disintegration, unless improper converting temperatures are employed. The magnetite coating has a melting point some 300° C. higher than the temperature at which converting takes place, which is a good margin in favor of the maintenance of the coating. And since the deposition of magnetite can be controlled by regulating the proportion of silica supplied to the matte, a converter once lined and coated should, in theory, never require relining. Practically the effect is to greatly prolong the life of the converter and to reduce converting costs by securing greater duty per lining.

Basic linings of magnesite brick in copper converters have been in use only a few years, but during that time they have abundantly proved their superiority. Steady improvement in the process of basic converting has followed the successive adoption of the method at Baltimore, Garfield, Anaconda and Great Falls. Basic linings protected as above described have lasted over two years, which is in marked contrast to former practice, either acid or basic. The patent claims on the process are broad, not being restricted to the deposition of magnetite on basic linings, but generally to the process of forming monolithic furnace linings by the oxidation of base-metal components of the converter charge.

How the World Pays for Engineering Progress

The subject of the cost and price of any commodity is one of the most difficult in the science of economics. In practical affairs, between buyer and seller, it is likewise a hard proposition. But it is logical to conclude that the cost of production is the integrated amount of human effort measured in terms of "men-days"—for the work of the unskilled laborer for one day is a proper and sound unit for such a purpose—which is given by the world in the production of the commodity under question. To measure this amount is quite another question. We suppose it is natural to assume that the average price less a certain profit apportions this accurately. In the final analysis, there exists a certain charge more or less incommensurate but still actual. This charge is the price the industry pays for the immense amount of unproductive experimenting.

The fact that the community pays for the failures of any enterprise is shown by the remark so often made that it costs more to mine gold than the gold is worth and that the losses of the failures are not paid for by the profits of the successes. We believe that this is not

strictly true but that there is an element of truth in it, and that it is widely true that the high profits derived from successful attempts to gain mineral wealth include insurance against failure. Mining engineers who lay the proper stress on the commercial side of mining insist that mining stocks should return from 10 to 20 per cent on the market value to allow for the exhaustion of mineral and to recompense the investor for previous losses. This is only right.

It is plain that the same conditions hold in the case of a reduction works that treats a crude mineral and produces a commodity useful to the community. There is always change, for the only thing unchangeable is human mutability. After countless failures a successful new process brings it about that the old plants must be "scrapped." So we see that in the constant flux of metallurgy there is always progress and that new processes when "practicalized," thereby render the old plants obsolete and make mines of deposits whose ores were commercially unavoidable. This, of course, has the effect of annihilating or at least depreciating the value of existing plants.

In any proper system of accounting there should be a charge to cover this loss. In electrical engineering where progress is rapid and sure this is set down under the item of "depreciation due to the advance in the state of the art." We have pointed out that in metallurgical engineering the changes proceed slower and with less apparent certainty than in electrical engineering, due to the fact that "commercial inertia" is greater in the former art than in the latter.

But in the metal business, progress though seemingly slow and made by saltations, is none the less an inexorable condition of existence. It is, moreover, costly and the world pays the reckoning in the price it pays for iron, copper, lead, zinc, and the other metals.

It is well known that pioneers in the introduction of any new process struggle along now intelligently, now aimlessly, and only attain progress by perseverance. We have the word of Sir Roberts-Austen that Sir Henry Bessemer made seventeen different types of steel converters before he hit upon a satisfactory and practical form of apparatus. Then, too, it was much improved by Holly and others in America.

It seems to be indubitable in view of the great amount of time, human energy, and money expended in the endeavors to "practicalize" new processes, that in any broad analysis of metal prices and metal costs, the consumer finally pays for all of it. For instance, take the case of improvements in the metallurgy of complex zinc-lead sulphides. A low estimate of the cost of attempts to develop the alluring hydrometallurgical processes, whose name is legion in association with that of zinc, is $15,000,000. In one sense this is all wasted. But in no other way does the world learn what can be done and what cannot be done, and if a successful process of any kind be developed, the returns to the world will be vastly greater than $15,000,000.

We see in the evolution of the fauna and of the flora that nature shows an equal and similar ruthlessness. She progresses slowing, evolving out of her wayward children the "sports," which are variations from the normal of existing species, a new type that is fitted to the new environment. But hardly one out of the myriad of "sports" is the successful variant that is the ancestor of the type of the future. There is, or rather there seems to be, a vast amount of unintelligence in the means by which nature progresses.

To have seen clearly in this apparent unintelligence, an ever-present intelligence that guides the force of nature, this must be placed to the credit of Henri Bergson and explains his immense present popularity among philosophizing humanity. This French Jew has superinduced upon the naturalistic philosophy of Herbert Spencer a lofty and noble spiritualistic superstruction. He typifies in his clear-cut idealistic thought, harmonizing so accurately the emotions and reason, the genius of his race and the genius of his country. He shows in his "Evolution Creatrice" that nature is really the embodiment of intelligence and that evolution is broadly constructive rather than narrowly destructive. His argument is at once sound and as brilliant as are his conclusions inevitable.

On the analogy of his philosophy we see a similar process going on in metallurgy. The useless experiments are unintelligent in one light and intelligent in another light. The sum total of all is progress and progress is the result of the victory of intelligence over inanimate obstacles. Continuing the line of Bergson's thought, it is reasonable to expect that the increased diffusion of applied science will tend to make the cost of progress less and to decrease the bill that civilization charges its inhabitants for metals, the sinews of its warring existence.

The Proof of Puddings and Processes

An old proverb gives a concise and positive rule for determining the value of a certain product of the culinary art, advising us that only in the eating of a pudding are we to find absolute proof of its worth.

In view of the many new chemical and metallurgical processes constantly seeking public favor, it seems proper to paraphrase the above proverb and say that the proof of a process is in the bookkeeping. Good metallurgy lies in making money out of ores, and processes which do that successfully have value. It matters not how ingenious a process may be, nor is it always of consequence that the chemistry and mechanics involved are correct; if the net result is not going to yield more dollars than are spent, the process has no commercial value.

One difficulty in arriving at the value of inoperative processes is that actual figures are not available to show the costs of the various steps. And unless an engineer has data gleaned from similar steps in other allied industries he cannot arrive at a safe approximation of profit and loss. If the proposal is wholly novel its cost may be roughly estimated, but in some cases nothing but an actual test, carefully checked by weights and assays, will reveal the truth. The intrinsic meaning conveyed by the old proverb is a good guide in valuing processes.

Readers' Views and Comments

Concentration of Carnotite and the Work of the Bureau of Mines

To the Editor of Metallurgical and Chemical Engineering:

SIR:—In your issue of February, 1914, I note an extract from Bulletin 70, Bureau of Mines, on the "Concentration of Carnotite by Wet and Dry Methods." According to both the government bulletin and the extract in your journal, it would seem as if the work on concentration of carnotite ores was made public for the first time in the preliminary report by Dr. Moore and Dr. Kithil. This, however, is incorrect.

Up to within the year 1912, it was considered a practical impossibility to concentrate said ore, due to its very fine physical structure. In a report printed by the Colorado Bureau of Mines, 1905, you will find this statement substantiated by Messrs. Fleck and Haldane of the Colorado School of Mines. After some personal research during 1911 and part of 1912, I was convinced that the wet concentration of carnotite ores was a commercial possibility. The results of my investigations, giving data, describing process, and showing the advantages gained by such an operation was published in METALLURGICAL AND CHEMICAL ENGINEERING, in June, 1912, fully one and one-half years previous to the Bureau of Mines' Bulletin 70.

SIEGFRIED FISCHER.

Metallurgical Department, Lehigh University,
So. Bethlehem, Pa.

The Induction Furnace—Its Efficiency and Refining Capabilities

To the Editor of Metallurgical and Chemical Engineering:

SIR:—In your February, 1914, issue Mr. I. Rennerfelt has brought up a few questions which it might be worth while to discuss a little further as there seems to exist quite some confusion regarding same. I mean the efficiency of various types of electric furnaces and the possibility of refining in induction furnaces. In the following I will confine myself to induction furnaces as I am more familiar with these than with "arc resistance" and "arc radiation" furnaces.

As regards the variance of information regarding the first point it is probably explained by saying that usually not all the factors are taken into consideration in calculating efficiencies and that various statements regarding "efficiency" are not directly comparable as they are based on different assumptions.

When a certain efficiency is stated, the conditions of operation as well as size of furnace, etc., should also be stated.

In the following I will first give an example showing that the efficiency of a furnace will be different under different conditions of service. The figures used are not quoted from furnaces in operation, but merely assumed to illustrate this fact.

Assume that a 20-ton induction furnace is used for melting cold scrap and that the theoretical power consumption per ton of steel which, of course, is the same under all circumstances, is 460 kw-hr. per metric ton; further, that the radiation loss of such a furnace is 7500 kw-hr. per twenty-four hours, and the electrical loss 3 per cent.

Assume also that in Case "A" 70 tons are melted per day, and in Case "B" 50 tons per day.

	A K.W.H.	*B* K.W.H.
Theoretical power consumption per day, about	32,000	23,000
Radiation loss per 24 hrs., about	7,500	7,500
Electrical loss at 3 per cent, about	1,200	940
Total	40,700	31,440
K.W.H. per ton	580	630
Efficiency	$\frac{32,000}{40,700} = 79\%$	$\frac{23,000}{31,440} = 73\%$

As will be seen, the efficiency in the first case is 79 per cent, in the second case it is 73 per cent. I wish to point out that when a certain efficiency is stated, it must always be explained what is meant by it.

If, on the other hand, someone makes similar calculations as above, but instead of regarding the efficiency as has been done here, he means by these terms the ratio between the power consumption per ton of steel figured out and the actual amount arrived at in practice, which might be somewhat higher on account of inaccuracies in the figures assumed, say 15 per cent higher, he will then state that the efficiency is 85 per cent in both cases.

Regarding the other point, the possibility of refining steel from phosphorus and sulphur and deoxidizing it in induction furnaces, I agree with Mr. Rennerfelt that the engineer who is not an electrometallurgist might be bewildered by the different statements made in this respect. As far as I am personally concerned, I am perfectly satisfied with the knowledge that there is no difficulty at all to refine in induction furnaces, and I wish to make a few remarks which might explain a number of things.

When Kjellin for the first time made steel commercially in an induction furnace in Gysinge, he made use of a furnace consisting merely of a circular channel containing the steel wherein the heat was generated. This channel was covered with lids. Now in order to refine steel for the removal of phosphorus and sulphur the following operations have to be performed:

The steel is first to be covered with an oxidizing slag which absorbs the phosphorus; this slag has to be removed and a new basic slag added to absorb the sulphur. In order to remove the first dephosphorizing slag from the steel in the Kjellin furnace the lids had to be removed and the slag lifted up. When the lids were removed a very large amount of heat escaped, the slag cooled off, and, of course, it was very difficult and time-wasting to remove the slag by lifting it up. It was hardly possible to remove it all. Consequently it was hardly possible to remove the phosphorus since during the following deoxidizing and desulphurizing operations the phosphorus absorbed in the slag, remaining in the furnace, was again reduced and entered the steel again.

The information was, therefore, spread broadcast that the induction furnace could not be used for refining, and also that the slag was not sufficiently fluid. This was true in regard to the first Kjellin furnace whereas in the Roechling-Rodenhauser furnace and the improved type of double-ring Frick furnace there is no difficulty at all in refining the steel or keeping the slag fluid, especially when they are made tilting, and with lateral doors, which latter arrangement goes a long way toward decreasing radiation losses.

As regards the statements made several times that the slag must be like a watery liquid and overheated to a high degree in order to be able to absorb sulphur and hotter than the steel, I think these are exaggerating statements. The only condition necessary, with the

exception, of course, of conditions as to composition of slag, etc., is to have the temperature at the surface between the steel and the slag, which is the place where the reactions take place, sufficiently high. Even assuming that it should be necessary to keep the slag in a watery condition, this can be done in an induction furnace by merely increasing the temperature in the furnace. Of course, the steel will also get hotter, and it has been said that it will be overheated. What is the meaning of this? The steel covered by a protecting layer of deoxidized quiet slag which, at no point allows possible air or oxidizing gases present to attack it, cannot possibly be injured by a very high temperature derived from the heat which is generated in the steel itself.

WILLIAM BJÖRKSTEDT.

New York City.

The Patent Processes for Making Casing Head Gasoline

To the Editor of Metallurgical & Chemical Engineering:

SIR:—Within the last few years the industry of producing gasoline and light boiling fluids from casing head gas and some natural and artificial gas has become a large industry and many patents on the subject have appeared and many patented processes are being developed. In some cases the patents have only been applied for and in others patents have been granted.

Under our patent system each application is examined to ascertain whether the applicant has any invention and no matter how small a part of a process an invention is, a patent may be obtained on this new feature. This novelty may be actually useful or necessary to success or it may be only asserted to be useful by the applicant. No question is usually raised as to usefulness of a patent by the patent office, as it is left for future development to show that. One may also secure a patent and yet not be able to use it on account of the prior patents dominating him. Also the patent office examination is not accepted by the courts as complete or really having much weight and when the patent is litigated in the courts a prior patent may be held to render the later one invalid.

On this account a prospective investor in patents must know something of the previous patents and what is known as "the state of the art."

A brief review of the art and patents should therefore be of timely interest.

Of course, it has always been known that there were so-called "wet gases," particularly among the "casing head" gases or those coming from a well in which oil was also produced. It was known that the gas contained oil and that the oil contained gas. The patent to Grieg and Smith, No. 42,121, of 1864, states that "Petroleum on being taken from the wells contains a large quantity of gas which when separated from the oil can be used for fuel."

This patent only discloses a method of ridding the oil from gas by blowing air through it.

In 1866 Johnson received patent No. 54,917, which clearly discloses the art of "rendering liquid the vapors which rise with or are forced up with petroleum." These are "light benzine, naphtha, etc."

The specification discloses the compression of the vapors by means of "lift or force pump" . . . "connected to a suitable condenser from which I gather the condensed liquid products into barrels," etc.

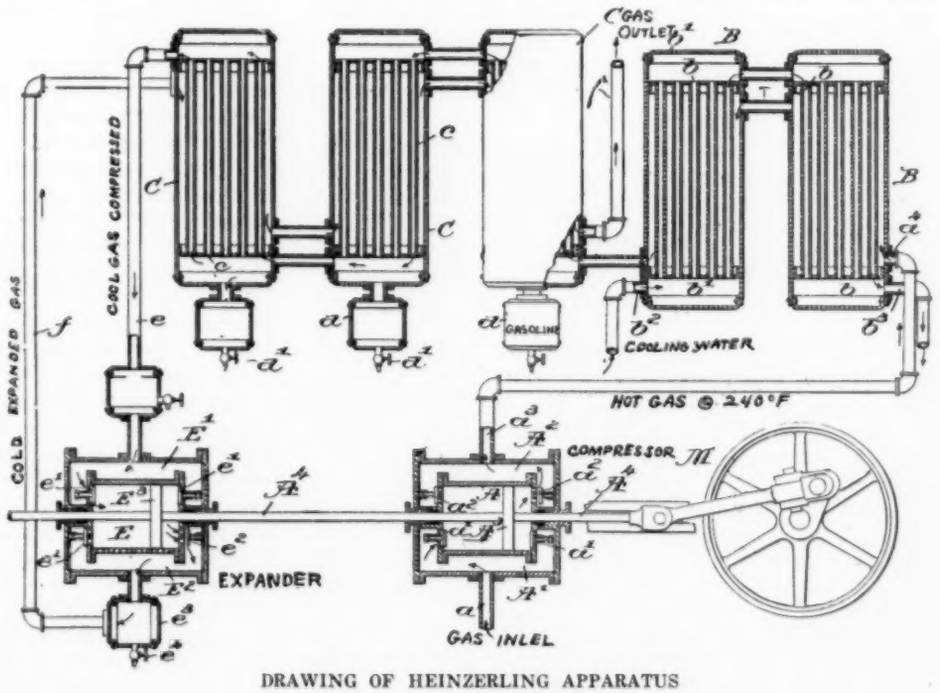
He states: "I employ power to actuate the pump."

His claims include "a new article of commerce, viz., the light condensable vapors which rise with petroleum and which may be pumped off under any suitable seal and condensed."

Here is clearly disclosed the primary operations of compressing casinghead gas and condensing out "the light benzine, naphtha, etc."

Consequently there can be no patents in existence which dominate the two primary operations necessary to produce casinghead gasoline.

In carrying on any commercial operation, economy is, of course, necessary and apparatus working in an economical way is, of course, an essential, but in the Heinzerling patent of 1897, No. 575,714, which expired Jan. 28, 1914, there is shown an air compressor or gas compressor cylinder and a gas expansion cylinder, both coupled to a flywheel with a series of condensers and heat exchangers between. The specification clearly explains that the gas is to be compressed in the first cylinder and cooled in two condensers in series; with



DRAWING OF HEINZERLING APPARATUS

condensation of the condensable liquids, which are removed by appropriate valved containers depending from and connected with the condensers. Thence the water-cooled gas passes to other condensers cooled by the residual gas which is meantime expanded in the second cylinder, which thus aids the compression. The expansion produces cold gas which afterwards, circulating through the last condensers, cools the compressed gas to a point stated to be between —25 and —40 deg. C. The first water cooling refrigerates the gas, as stated, to 10 deg. C.

Furthermore, this patent discloses the cooling of the gases by direct contact with cooling liquids such as calcium chloride and glycerine.

It states that "petroleum, benzine" and some others are not soluble in glycerine. The patent states "this

method of direct cooling by liquids is limited, as the substance to be separated must be insoluble in the liquid."

While this patent is not specifically directed to the production of casinghead gasoline, as the applicant was a German who probably never knew anything about this gas, yet the patent covers broadly any gases containing a volatile liquid, and the same machinery and process can be used on any gas, and no subsequent patent can claim any special gas unless it is shown that the special gas acts differently than any described in the patent.

It would appear, therefore, that the field is open to anyone to produce casinghead gasoline by using compression and condensation broadly or to use compression and water cooling on a gas and to subsequently expand the gas in a steam cylinder to help the compressor along, and that while compressing, the gas may be cooled with water, calcium chloride or glycerine, and further that the expanded gas may be used to cool the compressed gas by means of any heat interchanger.

In most of the processes now in successful work all the necessary steps are comprised in the above enumerated steps, which are old, as disclosed by expired patents.

It is unfortunate that in the Government publications particularly "Technical Paper No. 10 of the Bureau of Mines," entitled "Liquefied Products of Natural Gas," published in 1912, no mention is made of the above patents, though an extensive bibliography is given in the back of the pamphlet of which very little before 1911 refers to natural gas. The knowledge of the contents of the above patents throws a light on the patent situation which cannot be gained from any of the references cited in the bulletin.

The existing patents will not be criticised in any way except to state that they must all be construed in the light of the previous art as shown by patents above cited which have expired.

Among the earlier unexpired patents is No. 668,197 of 1901, issued to Le Sueur, which claims a process of liquefying "methane" from natural gas. The process described would not seem to liquefy methane, but it would liquefy the higher hydrocarbons of the methane series found in the gas. This is shown by the following statement occurring in the patent: "For instance, the liquid may be produced in the first place (from natural gas) by high pressure and fractional distillation induced thereafter by relief of pressure." This patent therefore discloses the compression of natural gas and a subsequent fractional distillation of the liquids produced. This would seem to disclose a system of producing different liquid products by fractional distillation after condensation.

While the disclosure quoted is in the specification and not in the claims it is sufficient to invalidate any subsequent patents which might broadly claim this process.

In 1907 patent No. 867,505 was granted to Dennis Hastings and W. Brink. It discloses that natural gas "after being artificially compressed" is brought into contact with water which serves to cool the gas; later "water or oil" is "atomized" to "intermingle with the gas" to cool it. This discloses the use of a "washing oil" to condense the lighter oils of the gas. It further discloses separating the cooling fluid and the condensed gasoline. This process is not claimed, but is an estoppel of later patents. The claims are for an arrangement of apparatus.

In 1909 John L. Gray obtained a patent, 993,976, for certain apparatus for obtaining casinghead gasoline from the gas. The claims are for an organization of apparatus for separating, first, any engine or cylinder oil from the gas by means of the ordinary steam trap or oil trap used on steam lines; a condenser with another oil trap beyond and a relief valve which is an ordinary steam safety valve. There is also a pot steam trap to separate the condensed gasoline from the gas and a receiving tank.

Subsequent patents will not be commented upon, the intent of this article being to point out the things which are undoubtedly old in the art and which are free to the public.

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The Iron and Steel Market

The buying movement in steel products referred to in last report has proved to be as satisfactory in results as was expected, since by early February it brought the steel mills up to an operation at an average of about 70 per cent of capacity, and this rate was maintained throughout the month, comparing with an average operation of about 55 per cent in January and an average of less than 50 per cent in December.

In February strictly new buying decreased somewhat, indicating, with the fact that the mills did not move up to operating at full capacity, that the increased buying of January was rather a temporary movement, caused chiefly by the fact that buyers acquired confidence in prices, after a decline of many months, and covered both to replenish their stocks and to provide a moderate tonnage for the future. A large part of the business booked was in the form of definite orders, with specifications attached, but there was also a fairly large volume of contracting, chiefly for first quarter, but in the case of bars, plates and shapes the majority of contracts were made to run through the second quarter also. Specifications against such contracts have been good during February, and the total volume of specifications for all steel products in February probably exceeded the aggregate for January, though as the latter part of January was much more active than the fore part, the average of February probably did not indicate as much pressure as the latter part of January.

With market conditions as they are at present the mills are not promised a heavier operation than 70 or 75 per cent in March or April, but in most quarters the interest of buyers in the market is expected to increase as time passes. The advent of spring is expected to bring heavier consumption in general, while it is believed that the railroads will soon have to buy more freely than they have in recent months. Thus far this year railroad material is estimated to have constituted between 10 and 15 per cent of the total tonnage purchased, whereas the normal requirements are estimated at about double this proportion. The matter of railroad buying is generally held to hinge upon the treatment accorded the railroads by the Interstate Commerce Commission, and particularly as to the case of the eastern railroads, demanding permission to make a general advance of about 5 per cent in freight rates. It is possible that the influence of the expected decision is being overestimated, as to its effect upon railroad policy in the long run, though there is no question that on account of the pendency of the advanced rate case the railroads adopted a definite policy of holding back their orders. While the advanced tariffs have been suspended until September 12, there is reason to expect a decision between May 1 and July 1, and there is increased expectation that some advances, if not the entire 5 per cent asked, will be allowed.

Monday, February 2, a great many announcements were made of advances in steel products. Some of the indicated advances held, while some did not. The American Steel & Wire Company advanced its prices $1 a ton, to a basis of $1.60 for nails, and the independents followed. About January 1 there had been a short

period in which business was done on a basis of $1.50, the market later advancing to $1.55, and the effect of the advance to $1.60 has been to bring in specifications on $1.55 contracts. The National Tube Company advanced standard steel pipe one-half point, the independents promptly following, and this advance has had the effect of greatly increasing the volume of specifications on old contracts. Oil country goods were also slightly advanced. The majority of large steel producers announced an advance in bars, plates and shapes, naming 1.25c. as their lowest quotation on these products, for early delivery, with 1.30c. for second quarter contracts. It quickly developed that business could still be booked at the lower level, in the case of attractive tonnages, while second quarter contracts could be placed at 1.25c. The Carnegie Steel Company, however, did not recede, and still maintains 1.25c. as its minimum, while it will not sell farther than three months ahead, except on specific jobs. On bars and plates the 1.20c. price can easily be done with several mills for early shipment, while on structural shapes such a quotation is relatively infrequent.

Pig Iron

The buying movement in pig iron which was clearly marked in January extended into the first week or two of February, the market afterwards becoming decidedly quiet. The buying was sufficient to advance the market fractionally, but was not of sufficient volume to require the blowing in of any number of idle furnaces. Resumptions of blast furnaces to date have been almost exclusively of steel works furnaces. It would appear that consumers as a rule are covered to April or July for tonnages equal to their present rate of consumption, while the operating furnaces are equally well sold up. There is no prospect of consumption decreasing, while any considerable increase would doubtless require the blowing in of additional furnaces, stocks being very light. The great majority of the furnaces now idle blew out before the market had reached a level as low as at present, hence it seems fair to assume that before many of them blow in a decided advance will be required. Coke has proved stronger than expected, while Lake Superior ore for the 1914 season may bring about as much as in 1913, whereas late last year the expectation was that there would be a reduction to the 1912 schedule, this meaning 65 cents reduction on Bessemer and 55 cents on non-Bessemer. The decline in pig iron seems to have discounted such a reduction in ore, and if a smaller reduction is made, or no reduction, the tendency would be for pig iron to advance. The market stands quotable as follows: No. 2 foundry, f.o.b. Birmingham, $10.50 to $11.00; No. 2 X foundry, delivered Philadelphia, $15.00 to $15.25; No. 2 foundry, f.o.b. furnace, Buffalo, $13.00 to $13.25; No. 2 foundry, delivered Cleveland, $13.75; No. 2 foundry, f.o.b. Chicago furnace, $14.00; at valley furnaces (90 cents higher delivered Pittsburgh); Bessemer, $14.25; basic, No. 2 foundry and malleable, $13.25; forge, $12.75. Imported ferromanganese has been advanced by stages from $35 to $39, Baltimore, with $2.16 freight to Pittsburgh.

Steel

About the beginning of the month the leading mills advanced prices on billets and sheet bars a dollar a ton, to $21 for billets and $22 for sheet bars, with $1 additional for second quarter, f.o.b. maker's mill, Pittsburgh or Youngstown. A few odd sales have been made at these advanced prices, but in general consumers are well covered to April 1 and in exceptional instances there are contracts to July 1. Forging billets have stiffened materially and are generally held at about $26, Pittsburgh. Rods are $26, Pittsburgh.

Finished Steel

Prices named below are f.o.b. Pittsburgh, unless otherwise stated:

Rails, standard section, 1.25c. for Bessemer, 1.34c. for open-hearth, f.o.b. mill except Colorado.

Plates, tank quality, 1.20c. to 1.25c.

Shapes, 1.25c.

Steel bars, 1.20c. to 1.25c., base.

Iron bars, 1.35c., Pittsburgh; 1.27½c. to 1.32½c., Philadelphia; 1.12½c. to 1.15c., Chicago.

Wire nails, $1.60 per keg, base; plain wire, 1.40c., base.

Sheets, blue annealed, 10 gage, 1.40c. to 1.45c.; black, 28 gage, 1.95c. to 2.00c.; galvanized, 28 gage, 2.95c. to 3.00c.; painted corrugated, 28 gage, 2.15c. to 2.20c.; galvanized, corrugated, 28 gage, 3.00c. to 3.05c.

Merchant steel pipe, ¾ to 3-in., 79 per cent. off list.

Steel boiler tubes, 3½ to 4½-in., 71 per cent. off list.

Standard railroad spikes, 1.45c. to 1.50c. Pittsburgh, 1.50c. to 1.55c., Chicago.

Structural rivets, 1.70c.; boiler rivets, 1.80c.

Cold rolled shafting, 64 per cent. off list.

The Western Metallurgical Field

Developments at Leadville

Ever since the discovery of zinc carbonate ore at Leadville there has been talk about building a treatment plant there to handle the low-grade ores that could not be shipped to the smelters in the Middle West. It is definitely known that there is a considerable tonnage of such ore, containing from 14 to 18 per cent zinc, that has not been salable. In the aggregate it could support a treatment plant, provided a profitable metallurgical scheme could be devised, and several individuals and companies have considered the feasibility of entering this field. Hydrometallurgical processes have been tested, and pyrometallurgical concentration prior to smelting also has been proposed.

Within the past thirty days, however, the possibility of erecting a treatment plant at Leadville has assumed more definite shape, and as the project is in the hands of experienced zinc smelters it is receiving more serious attention than has been given to previous proposals. Messrs. Augustine and Jones, formerly associated with the American Metal Company's zinc smelters at Collinsville and Bartlesville, Okla., have visited Leadville on a trip of inspection of the mines. It is reported that they have contracted for the ore supply from at least one mine, and have investigated possible sites for their plant. They propose to produce zinc oxide from low-grade carbonate of zinc, but the details of their process have not been announced. The commercial phase of the matter is all-important, and probably has received the careful attention of the promoters. If the plan is carried out the plant will be erected this summer and be in operation by fall.

Prospects are again bright for the unwatering of some of Leadville's older mines, particularly the downtown district. A new scheme is being promoted by ex-Governor Jesse F. McDonald, who is securing long-time leases on mines in the vicinity of the Penrose shaft, with the intention of pumping water at that point.

Organizations of Mining Men

Colorado and Utah mining men have organized for the purpose of securing for the mining industry the recogniation which they feel is due to the leading industry of those states. The meetings, which were held in Salt Lake City and Denver, occurred too late

to be reported in this issue. It is a regretable fact that mining men have not stood together in matters relating to their industry, with the result that legislatures have passed inane laws vitally affecting mining in an adverse way. One particularly flagrant sample of this is the mine taxation law passed by Colorado's last legislature, without so much as a serious protest on the part of mining men. Their attention was called to the bill, but they regarded it as too outrageous to be considered seriously. Apparently, however, nothing is too foolish or unfair to get past some of our legislative bodies if there is no concerted protest. Mining men have only themselves to blame if they do not unite to create a strong sentiment in favor of a fair recognition of their industry, and it is hoped that something good will come out of these efforts in Utah and Colorado.

Prospecting for Carnotite

The proposed action of the federal government in withdrawing carnotite deposits from private exploitation has resulted in a rush of prospectors to the districts where these ores have been found, also in the "discovery" of several new districts. A great deal of this feverish excitement has been created and fostered by the daily papers, which have printed the most absurd statements regarding the value of the ore and the extent of the deposits. Thus, for example, one district is said to contain "100,000,000 pounds of radium ore which will make between 100 and 150 ounces of radium, worth more than $900,000,000." The Colorado deposits, we are informed, are low-grade, and consequently are converted into "pitchblende ingots" before shipping East. With such glittering prospects held before the uninitiated, it is not surprising that they have been induced to search for this newest El Dorado. That they will return rich in experience and with a dubious regard for radium is a foregone conclusion.

The production of uranium, vanadium and radium in 1913 has been reported by F. L. Hess, of the Geological Survey. Fifty tons of pitchblende containing 1.49 per cent U_3O was shipped from the Kirk mine in Gilpin county, Colorado. The Belcher and Calhoun mines in the same district sold only a few pounds of the same mineral. The shipments of uranium and vanadium were equivalent to 38 tons of U_3O, and 914 tons of V_2O. These quantities are equivalent to 32.3 tons metallic uranium and 412 tons metallic vanadium. The recoverable radium from the uranium ores is estimated at 9.79 grams of metal, worth $120 per milligram, or a total value of $1,055,000. The value of the carnotite ores sold was about $142,000, which represents the uranium value only, as little or nothing was paid for vanadium. The production for 1913 was the largest yet made.

Copper Hydrometallurgy

Among the companies now investigationg the hydrometallurgy of low-grade copper ores is the Nevada-Douglas, owning mines in Nevada. Tests have been under way in Denver at the plant of John E. Greenawalt, and while the work is not yet completed the results are very encouraging. The company has recently made public the statement that the cost of electrolytic precipitation is 1.38 cents per pound of copper, and gives an estimate of 8 cents per pound as the probable total cost of producing copper, including mining, treatment and freight charges. The Greenawalt cell differs from others in having the electrodes arranged horizontally instead of vertically, with only one anode and cathode in each shallow vat, the anode being uppermost and only slightly submerged. The solutions are saturated with sulphur dioxide prior to electrolysis.

The Bureau of Mines and Utah

About a year ago Utah provided for the establishment of a metallurgical research department at the School of Mines of its State University, the purpose of the department being "to conduct experiments and researches, either alone or in cooperation with the National Bureau of Mines and other agencies, with a view to finding ways and methods of profitably treating low-grade ores, of securing a higher percentage of extraction of metals from their ores, and of obtaining other information that shall have for its object the benefit of the mining industry." Almost a year elapsed before a beginning was made to carry out the provisions of the law. Recently the Bureau of Mines sent Mr. Dorsey A. Lyon and Mr. Robert M. Keeney to Salt Lake City to start the work, and it is now under way.

Quicksilver In Nevada

At Ione, Nev., the Nevada Cinnabar Co. has completed a modern plant for the treatment of mercury ores, and expects to commence operations this month. The company owns about 600 acres of land from which the ore will be mined by quarrying from open pits. The plant is operated throughout by electric power, and the furnace has a capacity of 50 tons daily. It is expected that ore containing 1 per cent mercury will be handled profitably.

Company Reports

The Portland Gold Mining Co. reports unusually satisfactory results from its operations during 1913. The net earnings amounted to $604,443, of which $300,000 was paid in dividends. Ore mined and shipped to the remodeled mill at Colorado Springs amounted to 53,245 tons, of an average value of $25.93 per ton. The mine also produced 127,054 tons of low-grade ore, much of which was taken out in course of development. This, together with 51,108 tons of low-grade ore taken from the dump, constituted the material treated in the new Victor mill. The average assay value of this material was $2.95 per ton. Extensive development is planned this year for the seventeenth level of the mine. The Roosevelt drainage tunnel is lowering water in the mine at the rate of about 8½ feet per month, and will drain the property to a further depth of 500 feet. The Victor mill was enlarged during the year by the addition of an ore-bin, Chilean mill and eight concentrating tables. The report does not contain as complete data as usual on metallurgical operations.

From the quarterly reports of the **Nevada Consolidated, Chino** and **Utah** copper companies for the fourth quarter of 1913, the following data are tabulated:

	Nevada Con.	Chino	Utah
Ore milled, tons.....	833,989	429,750	2,113,080
Per cent copper.....	1.58	2.08	1.22
Copper produced, lb.	16,684,955	12,021,872	23,884,467
Cost copper per lb., c.	8.63	9.17	8.93
Extraction, per cent.	....	65.54	....

Camp Bird, Ltd., has issued a circular regarding conditions at the Santa Gertrudis mine in Mexico, in which it is stated that while the internal conditions in Mexico have not as yet affected the company's operations, it is deemed advisable to pass the half-yearly interim dividend in order to be able to meet any unforeseen contingencies.

The earnings have been ample to meet the dividend as usual, but it is deemed prudent not to disburse the same.

Mechanical Refrigeration—II

The Compression Refrigeration Cycle

BY H. J. MACINTIRE

The compression refrigeration cycle will not appear complicated if the essential duty of the machine is held in mind. It should be understood first that vapors only are used as refrigerating mediums and more particularly ammonia and carbon dioxide. These vapors are made to condense and form a liquid by being compressed sufficiently to allow of condensation with the cooling water present. The condensing pressure varies directly with the temperature of the cooling water, though the ratio is different for each vapor. Cooling water is absolutely essential and the cooler this water the more readily the vapor can be condensed.

Refrigeration is obtained by allowing the liquid refrigerant to abstract heat from its surroundings—the pressure under which the vapor does this being arranged as desired. The boiling temperatures of water under one atmospheric pressure is 212° Fahr., but under 150 lb. gage pressure it is about 365.6° Fahr. In like manner the temperature under which ammonia boils when its pressure is one atmosphere is — 26.8° Fahr., but at 15 lb. gage the boiling temperature becomes — 0.8° Fahr. Refrigeration, as we understand it, is simply the removal of heat at a temperature below that of the atmosphere. If a body is colder than the surroundings, heat flows from these surroundings to the cold body. Refrigeration may require, then, either the lowering of the temperature of a body below the atmospheric temperature or the maintaining of this low temperature.

In other words, the liquid refrigerant is allowed, then, to boil at such a pressure as will give the required temperature to the refrigerated object. This pressure is under the control of the engineer, by proper adjustment of the speed of the compressor and of the liquid refrigerant passing into the cooling coils.

THE REFRIGERATING CYCLE

Because an expensive refrigerant (or working fluid) is used—usually ammonia or carbon dioxide, as just mentioned—the refrigerating cycle is a closed one, and the fluid is used continuously. The cycle of operations, being composed of heat exchanges, can best be represented by a heat diagram as shown in Fig. 1. The ordinates are temperatures in degrees Fahrenheit absolute (zero ordinate being the absolute zero) and the abscissa are so chosen that an area on the diagram represents heat units in B.t.u.

The point 2 corresponds to the admittance of the liquid to the refrigerating coils. The pressure on the liquid had been that of the condenser, and in the cooling coils it is the so-called back pressure—an amount considerably lower. Point 2, then, corresponds to the expansion valve of the refrigerating cycle. During the drop of pressure the temperature has to decrease also according to the physical laws just mentioned. The only way in which this decrease of temperature is possible is to have a part of the liquid evaporated.

In the diagram 120 is a line representing the condition of the liquid, whereas 7*P* corresponds to that of a dry saturated vapor. The region between these two lines represents the condition of saturation. Evidently, then, a pound of the liquid refrigerant may be represented by some point as 1 on the liquid line. If heat is added and evaporation begins, heat will be supplied at constant temperature until all the substance is evaporated, and the process may be represented by the point moving from 1 to 7. The heat added (called the latent heat of vaporization) is found to be equal to the area below the line 17. Likewise the region to the right of 7*P* is that of superheat—an intermediate condition between that of saturation and of a perfect gas.

As the liquid passes the expansion valve at 2, then, it enters a condition of lower pressure and lower temperature, and a certain amount of the liquid, some 5 per cent to 15 per cent, is evaporated in order to lower the temperature of the remainder. Subsequent evaporation in the cooler is at t_s and is equal in heat units to the area under the line 3*P;* that is, the area 3*PS*8 is equal to the heat added (refrigerating effect) by the goods.

WET COMPRESSION

As refrigeration progresses the liquid is changed into a saturated or slightly superheated vapor which must again be returned to the condition of a liquid. The compressor serves this purpose. The remainder of the cycle, however, depends on the details of the compression as far as the capacity of the installation and the efficiency of operation are concerned. The wet compression—so-called—permits a small amount of liquid ammonia to pass into the cylinder of the compressor with the vapor. During compression the temperature of the vapor begins to rise, a tendency which is partly neutralized by the liquid injection, the latter absorbing heat by evaporation similar to the action of water in the old-style wet compression for compressed air machinery. If a large amount of ammonia is admitted the compression stroke may be represented theoretically by the line 47, but the usual wet-compression line is shown by 56, giving some 40 deg. of superheat at the point 6.

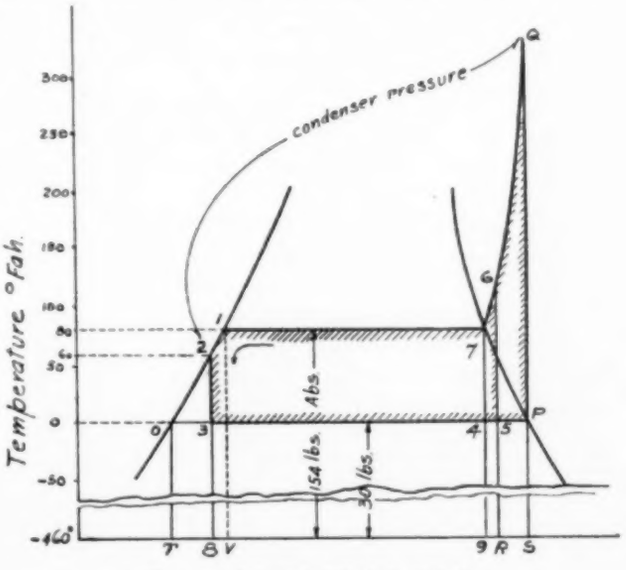

FIG. 1—REFRIGERATING CYCLE

DRY COMPRESSION

Another, and by far the more common method of operation, is to allow dry or slightly superheated vapor to enter the cylinder, which in this case is water-jacketed. The temperature at the end of compression is quite great, often 300 deg. Fahr. to 350 deg. Fahr., but full refrigerating effect is obtained from the ammonia, giving in Fig. 1 a theoretical advantage over the wet compression of 11 per cent and 8 per cent respectively. There are other operating factors which give decided advantages to the dry-compression cycle, such as greater volumetric efficiency, greater allowable piston speed, etc.

The compressed vapor is now exhausted into coils in metal contact with water. The water cools the re-

frigerant to approximately its own temperature during which time the heat due to the superheat $Q79S$, the heat of condensation $71V9$, and part of the heat of the liquid $128V$, are abstracted, thus bringing the substance back to 2, which was the point given as the beginning of the cycle. The refrigerating cycle, then, consists of a drop of pressure at the expansion valve, the evaporation at the refrigerating temperature, the compression, and finally the condensation at the upper pressure.

INDICATOR CARD

Let us consider the cycle from another standpoint—that of the work performed per compressor stroke. If we plot the pressures in the cylinder for various positions of the piston, the indicator diagram shown in Fig. 2 is obtained. Here, in contradiction to Fig. 1, the area of the enclosed figure is the work done by the piston on the vapor, and this is proportional to the total power supplied. It is usually important to keep this supplied power down to a minimum, and to do so certain things, as with air compressors, must be avoided.

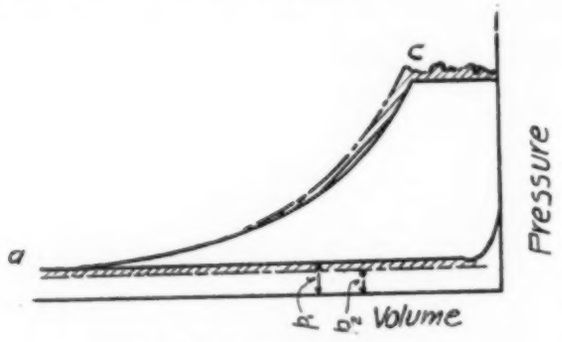

FIG. 2—INDICATOR DIAGRAM

These are wire drawing through the suction valve, excessive resistance to the vapor passage through the discharge valves, the valve ports and discharge pipes, and finally in the obtaining of as flat a compressor curve *ac* as is possible.

The compression curve has been given considerable attention and the compressors using oil or ammonia injection as a rule have a flatter curve than those using the water jacket only. The tendency at present, however, is to increase the piston speed; this fact alone would cause the former method to be abandoned as it was for air compressors twenty or thirty years ago. Although a maximum pressure of from 200 to 225 pounds is frequently obtained during compression, yet multi-stage compression for refrigeration is not used because of mechanical difficulties and the decided variation of the discharge pressure with change in the temperature and the quantity of the condensing water.

The shaded areas at the top and the bottom of the indicator card may be decreased by care in the design of the valves. Mechanically operated valves have not yet been used, even for the inlet stroke. The desirable net area of the inlet valve depends on the piston speed, and should be from 4 to 8 per cent of the piston area. In air compressors and blowing engines the suction valves frequently have from 14 to 20 per cent of the piston area, but these high values are for high piston speeds, much above the present refrigerating practice. The pressure p_1 corresponding to the suction pressure in the compressor should not be much greater than p_2 corresponding to the cooler pressure. Differences of pressure much over one pound should be investigated critically, likewise the maximum compressor pressure should not be much greater than the condenser pressure for the same reason.

CONDENSER PRESSURE

The condenser pressure depends directly on the temperature and the amount of the cooling water. Without cooling water refrigeration is practically impossible. As is seen in Fig. 2, the work of compression increases with an increase of condenser pressure, which is a little less than the discharge pressure from the compressor. It is, therefore, very desirable to use as cool condensing water as is possible, especially where use is made of motor-driven compressors.

Table I, which is the result of considerable experimentation, is taken from the Proceedings of the American Society of Refrigerating Engineers, 1906. In this table it is seen that one gallon of water per ton of refrigeration (a refrigerating effect equivalent to the abstraction of 200 B.t.u. per minute) at 60° is nearly equivalent to 1½ gallons at 70°, two gallons at 75° or three gallons at 80° F. As electric motor-driven compressors are becoming increasingly popular, the desirability of cool condensing water is very apparent.

TABLE I. AMOUNTS OF COOLING WATER

Table I—Amount of Cooling Water

Initial Temperature of Cooling Water.	Gallons of Water per Minute, per Ton. ½	¾	1	1½	2	3
50° F	226	163	137	114	...	...
55	245	178	150	126	...	...
60	...	195	165	139	127	...
65	...	212	181	152	140	...
70	...	231	197	167	153	140
75	...	...	215	183	168	154
80	...	...	234	199	184	169
85	...	...	...	217	201	185
90	...	...	...	236	218	202
Range	56	37	28	18.7	14	9.3

Liquid Refrigerant at Expansion Valve = 68° F.

Figures in table are condensing pressure in pounds per square inch gage.

The suction pressure, as already mentioned, is at the command of the operator and should be governed by the work to be performed. For instance, if air cooling down to 50° F. is desired, the boiling temperature of the refrigerant should be about 20 to 30° F. and not 0° or lower. The reason for this is to be found on the consideration of the specific volume at these temperatures. The volume of one pound of ammonia at 30° is 4.82 cubic feet, and at 0° it is 9.19 cubic feet or an increase of necessary displacement of the compressor (in work done and in capacity as well) of a little over 90 per cent. An advantage, however, is obtained in using the lower boiling temperature as far as the condenser is concerned, as the greater temperature difference on the two sides of the condenser pipes will allow a smaller area of condenser. The great increase in operating cost is apparent from what proceeds, however.

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Tungsten ores were produced by six western states in 1913—Colorado, California, Idaho, Arizona, South Dakota and Nevada. Boulder county, Colorado, was the largest producer, with an estimated output of 953 tons of ferberite. The total production for the United States was equivalent to 1525 tons of ore, carrying 60 per cent tungstic acid, WO_3. The Atolia district, California, was the second largest producer, and was the first in rank of scheelite producers. Prices generally ranged from $6 to $7.50 per unit of 20 lb. of WO_3, and were higher than in 1912.

Concentration tests on Mesabi iron ores have been made at the experiment station of the Minnesota School of Mines, and reported in Bulletin No. 2. A wide variation in grade of concentrates from crude ores of practically the same grade seems to indicate that the texture and character of the several sizes of material composing the crude ore are the criterion of washability, and not their chemical analysis.

The Manufacture and Uses of Blaugas

BY DR. HUGO LIEBER

William Murdoch's invention in 1792 of a process for the manufacture of an illuminating gas, and the first establishment of a commercial gas plant in Birmingham ten years later was destined to be rapidly developed and perfected, so that it soon became a commercial necessity. However, one of the disadvantages of this invention was the fact that it required a considerable investment of capital for the manufacturing plant and its maintenance, and especially for the equipment of gas mains required to conduct the gas to the consumer. Therefore, it was soon recognized that a gas factory could be commercially and successfully operated only in such districts which were thickly populated, and where a large number of customers could be connected with the gas mains and thus be made consumers of this commodity.

The great advantages derived from the use of gas were soon recognized and created a considerable demand for same, but owing to the limitations of a supply of gas to the territory traversed by the gas mains, and as beyond reach of these there was soon created a great and constantly growing demand for this commodity, many attempts were made to fill this demand.

These experiments resulted in various inventions of more or less value, having for their object the production of a compressed or condensed gas in such form that it would be commercially transportable beyond the reach of the gas mains.

In the experiments conducted by various investigators, coal gas as well as oil gas was used, but attempts to produce a commercially condensed and transportable coal gas were soon abandoned in favor of oil gas on account of the higher calorific value of the latter. The compressed oil gas is to-day still used very extensively, especially for lighting of railroads, buoys, lighthouses, etc.

The compressing and commercially adopting of such compressed oil gas was successfully done especially by Pintsch, and with such compressed oil gas is usually identified the name of Pintsch owing to the great introduction of the Pintsch system throughout the world, and such compressed oil gas is usually known as Pintsch gas.

Under the Pintsch system the oil is distilled at fairly high temperatures (900 deg. to 1000 deg. C.) so as to produce as large an amount of fixed gases as possible. These fixed gases are subjected to a pressure ranging from 5 to 16 atmospheres, in the United States 6 atmospheres being the prevailing pressure. As under the Pintsch system, after distillation and compression certain of the hydro-carbons are liquefied, these have to be removed, and only the remaining gaseous compressed hydro-carbons are permitted to enter the shipping containers.

A German chemist, Herman Blau, succeeded in making a great improvement in the production of a transportable compressed oil gas. He compressed oil gas to such a degree that the bulk of same was liquefied. The process employed by Blau is in brief as follows:

In the original process gas oil is conducted into the retorts the same as in the manufacture of Pintsch or other oil gas, and is vaporized and decomposed in these retorts under a temperature of about 550 deg. C. to 600 deg. C. This low temperature is employed in order to prevent the production of a large percentage of fixed gases, as contrary to the heretofore existing principle it was the desire of Blau to produce as large a quantity of the coercible hydro-carbons and as small a quantity of the permanent gases as possible. After the oil has thus been distilled, the gas obtained is conducted in the usual manner through hydraulic mains, coolers, cleaners and scrubbers in order to remove the tar which these gases contain. After this the gas is purified of its chemical impurities by being forced through chemical cleansing agents, where especially sulphide of hydrogen and carbon dioxide, etc., are removed. This being completed, the gas is conducted in the usual manner into large gas holders for storage purposes. With the exception of the difference in the temperatures employed in the distillation process, the Blau process up to this point does not vary materially from any of the other well-known processes of oil gas distillation employed heretofore.

Since its first introduction, the Blau process has been very materially and rapidly improved from time to time, these improvements having for their object the production of a better quality or a drier gas, and also the greater yield from a certain quantity of oil. In the original process as employed by Blau, the gas from the holder was drawn into a cooler where, under a suitable process, it was cooled considerably below zero in order to liquefy and discard at this stage certain of the coercible hydro-carbons which, in the finished product, were not desired; that is, such hydro-carbons which under normal pressure and temperature would again liquefy.

Under the new process as it is employed in the various Blaugas factories at the present time, this preliminary cooling has been discarded. The gas is drawn directly from the holder into the compressor which is usually a three-stage or four-stage compressor. The liquefying and discarding of those coercible hydrocarbons which are not desired in the final product now takes place in the first and second stage of the compressor, and the balance of the gas passes on into the third and eventually the fourth stage where the gas is compressed up to 100 atmospheres. During all stages of the compression water is injected into the compressing chambers for lubricating and cooling purposes. The water which is carried over after the final compression is separated from the liquefied hydrocarbons after the last stage of compression, and is then withdrawn from these by a suitable device. The refuse tar obtained from the cooled and scrubbed gases is collected in proper receptacles, and from there is pumped into tanks from where it flows by its own gravity to the retorts where, with compressed air or steam, it is sprayed under the retorts, and is thus used to supply all the heat required for these retorts.

As in the course of the manufacture and during the distillation of the oil a certain amount of permanent gases have been produced which the liquefied hydrocarbons have been unable to absorb, these permanent gases are conducted into large cylinders from which, by means of proper reducing and regulating valves, they are conducted into the engine where they produce all the power which is needed in a Blaugas plant.

The whole Blaugas process, as it is now employed, is so minutely worked out that but a very slight excess of tar and permanent gases is obtained beyond the quantities required for heating and power purposes. The final product consisting of liquefied hydro-carbons, and absorbed therein or dissolved thereby non-liquefied hydro-carbons, is of such composition that this whole aggregate will remain a liquid as long as same is under the pressure employed in the process, but these liquefied hydro-carbons will at once become converted into a gaseous aggregate if the pressure is reduced to approximately atmospheric pressure. These liquefied hydro-carbons are conducted into suitable steel cylinders or bottles for transportation purposes.

Under the compression of 100 atmospheres the oil

gas is reduced to 1/400 of its volume, the gas so obtained being of a specific gravity which is approximately the same as atmospheric air. One ltr., that is, 1.246 gr. of Blaugas at 0 deg. C. and 760 mm barometer contains 1.042 gr. carbon and 0.204 gr. hydrogen. This gas has a calorific value of about 1800 B.t.u. per cu. ft., or approximately three times the heat value of ordinary city gas.

The explosive range of Blaugas is lower than that of any other commercial illuminating gas, which the following table will show:

	FROM	TO	EXPLOSIVE RANGE
COAL GAS....	6.33% gas 93.67% air	19.33% gas 80.67% air	13%
ACETYLENE.	2% gas 98% air	49% gas 51% air	47%
HYDROGEN..	9.5% gas 90.5% air	66.3% gas 33.7% air	56.8%
BLAUGAS.....	4% gas 96% air	8% gas 92% air	4%

As has been stated before, the heat value per cubic foot of Blaugas is about 1800 B.t.u., whereas that of acetylene is 1500 B.t.u. per cubic foot and of hydrogen 425 B.t.u. per cubic foot. As the volume of Blaugas is reduced to 1/400 under its compression, it requires much smaller receptacles to transport a certain number of heat units with Blaugas than with any other gas.

Of the commercially transportable gases are to be considered acetylene, hydrogen and Blaugas, as Pintsch gas is a transportable gas in a limited sense only. Acetylene can be considered as a transportable gas only under the so-called "Acetylene Dissous" system. The following table will show the heat value per cubic foot, the container capacity, the weight of containers required for a given number of heat units, the number of containers required, and the price per 100,000 B.t.u.:

	HYDROGEN	ACETYLENE DISSOUS	BLAUGAS
Heat value, per cu. ft....	425 B.T.U.	1500 B.T.U.	1800 B.T.U.
Contents of a container of 1 cu. ft. water capacity	120 cu. ft.	100 cu. ft.	300 cu. ft.
Weight of containers required to transport a given quantity of heat units (for example 540,000 B.T.U.)	1060 pounds	432 pounds	100 pounds
Number of containers required to ship 5,400,000 B.T.U.	106	36	10
Price for 100,000 B.T.U..	$1.41	$1.00	44c.

Hydrogen per cu ft., 3/5c.
Acetylene Dissous per cu. ft., 1½c.
Blaugas, per cu. ft., 4/5c.

Blaugas is transported in steel cylinders of various dimensions ranging in size (water capacity contents) of from ¼ ltr. to about 100 ltrs. The size mostly used is a cylinder with a water capacity of about 27 ltrs., or about 1 cu. ft. This cylinder when properly filled contains about 20 lb. of Blaugas, which will become converted into about 250 cu. ft. of expanded gas when the pressure is released. As Blaugas contains no carbon monoxide it is a non-poisonous gas.

Blaugas is used mostly in such districts where no gas is supplied from a central gas plant through ordinary mains, but it is also used very extensively in districts where city gas is supplied, especially for steel and cast-iron welding and cutting, brazing, soldering, for laboratories and such purposes where a uniform gas with high heat units is essential.

In districts where gas is not supplied through mains or through a central plant, Blaugas is used for all purposes where otherwise city gas is used, namely, for illuminating, cooking, ironing, heating, and similar purposes.

The cylinders are attached by means of a reducing valve to a small expansion tank, and from there the gas is conducted into the pipe line by a pressure regulator. As Blaugas is under a high pressure when delivered to the consumer, it is a very simple matter to produce so-called pressure gas wherever same is required, pressure gas being very desirable for the production of brilliant illumination, one c.b.f. of Blaugas producing 80 candles in an incandescent Welsbach burner.

The first Blaugas factory was erected in Augsburg, Germany. This was rapidly followed by other factories in Budapest, Copenhagen, Bucharest, St. Petersburg, and Hoek von Holland. In the United States at the present time there are factories in Long Island City, St. Paul, Kansas City, Omaha, and Portland, Me. There are a number of factories now in course of construction.

Notes on the Gran-Annular Electrical Furnace

BY ZAY JEFFRIES

This is the name which has been given to the electric furnace invented by C. H. Fulton and W. A. Coursen. The name implies "granular" because the electric resistor is in the form of grains and "annular" because the grains occupy a space in the furnace the shape of a hollow cylinder. The furnace was described in 1912 by C. H. Fulton in connection with the investigation of slag.[1] Since then a few mechanical improvements have been made and considerable work has been done to ascertain the most suitable kind and size of resistor to use.

Description of Furnace

Fig. 1 shows the Gran-Annular electric furnace in cross-section. The essential features are given by the inventors as follows: (1) Two concentric cylindrical tubes, the inner one of which forms the heating-chamber, made either of magnesia or alundum, and the cylindrical space between which, when filled with a granular resistor, becomes the resistor cylinder. (2) A resistor of uniform cross-section throughout its length. (3)

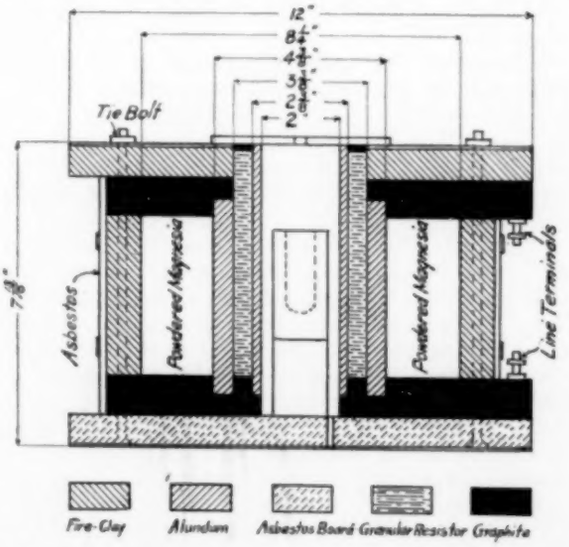


FIG. 1—CROSS-SECTION OF THE GRAN-ANNULAR ELECTRIC FURNACE

The positive and firm insertion of the tubes in the electrode plates, thus maintaining the resistor chamber in perfect shape. (4) That any part can be readily and cheaply replaced. (5) Simplicity and compactness of construction, preventing racking and distortion during heating.

A furnace with the dimensions given satisfies most of the laboratory requirements.

[1] Transactions American Institute of Mining Engineers, Vol. XLIV.

Resistors

Three materials are at present available, kryptol, granular carbon, such as is furnished by the National Carbon Company, and granular graphite, furnished by the Acheson Graphite Company. The curves in Fig. 2 show the variation in the specific resistivities of the three materials per cubic inch, with change in temperature. The furnace was used for the determinations. In each case the resistor was put into the furnace loose, i.e., with pressure due only to its own weight.

The hot junction of a platinum platinum-rhodium thermo-couple, protected by a quartz tube, was placed in the resistor, a distance from the top electrode equal to one-fourth the distance between the electrodes. The resistances were obtained by measuring the current and drop in potential between the electrodes.

Temperature and resistance readings were taken at the same time in fifteen-minute intervals. The temperature indicated by the thermo-couple is taken as the average of the resistor. That the average temperature

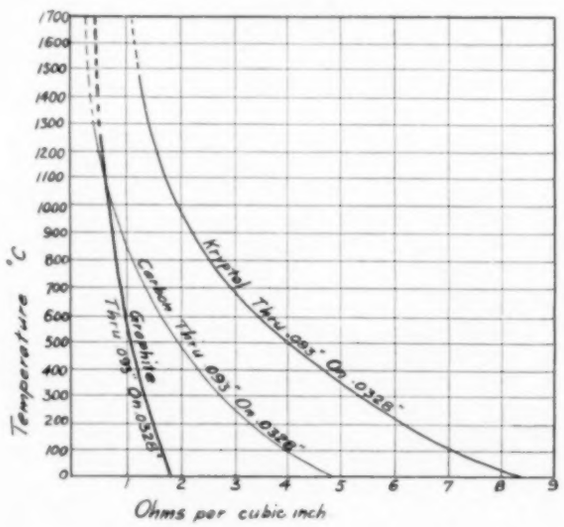


FIG. 2—TEMPERATURE, RESISTIVITY CURVES FOR KRYPTOL, CARBON AND GRAPHITE

was somewhat lower than the results given is highly probable for reasons that will appear later. The radiation of heat, however, is more active at the top electrode than at the bottom, a condition which tends to correct the error.

One thing common to all of the materials is the marked negative coefficient of resistivity. The writer offers an explanation for this which fits the facts in the case very closely.[3] A discussion of the theory is especially invited. In the first place, Acheson graphite has a much more constant resistance than is indicated by the curve.[3] The decrease in resistivity must then be due to an increase in contact area between the grains. This is brought about by the expansion of the grains with increase in temperature, wedging preventing the displacement of the resistor mass as a whole, and thus decreasing the resistance. This may be compared to a carbon plate rheostat, the expansion of the grains being analagous to increasing the pressure between the plates with a hand wheel.

Considering, then, that the decrease in resistivity of graphite is almost entirely due to the better contacts between grains, why do kryptol and carbon show larger decreases? Kryptol is a mixture of carbon and some dilutent which is probably not a good conductor of electricity and also probably contains some graphite. Carbon itself has a marked negative coefficient of resistivity, which, in conjunction with the better contacts, makes the negative coefficient of kryptol much greater than graphite. With this theory in mind it would seem that carbon alone would have a greater negative coefficient than kryptol. That this is true is shown by an example taken from the curves.

	Graphite	Kryptol	Carbon
0 degrees C.....	1.80 ohms	8.30 ohms	4.80 ohms
1200 degrees C.....	0.60 ohms	1.60 ohms	0.50 ohms
Ratio	3 : 1	5.18 : 1	9.6 : 1

At high temperatures in the presence of oxygen there is a condition which tends to increase the resistance. The contact points of the grains being the hottest will oxidize more readily than the cooler parts, and as wedging prevents the free settling of the grains by gravity, some of the contacts will have their areas reduced and others may be burnt out completely. With an excess of oxygen and at a very high temperature, this condition may overcome the negative coefficient and actually indicate an increase in resistance with an increase in temperature. This increase must be due to the reasons given because on cooling, the resistance increases further.

Comparison with the Platinum Wire Furnace

When compared with the platinum wire furnace the gran-annular furnace has two unquestioned advantages. (1) The cost is less than one-third as much, and (2) it can be used safely at temperatures 300 degrees C. higher than the platinum wire furnace. The current control, however, is better in the platinum furnace because the resistance is the same no matter how many times the furnace has been heated. The resistance of the gran-annular furnace increases slightly every time it is heated above 1200 degrees C. This is caused by air gaining access to the resistor through the pores of the inside alundum tube, when the furnace is opened, and oxidizing some of the carbon.

When the resistance gets so high that a short circuit through the furnace does not give as high a temperature as is desired, the resistor is poured out and the furnace is refilled with the same material. A similar result can be obtained by packing the resistor, but since unequal packing causes hotspots, the former method is used. One filling usually lasts from forty to fifty heats to a temperature of 1500 degrees C. It takes about five minutes to change the resistor. Although the resistance changes from heat to heat, during any given heat the current can be controlled within very narrow limits.

The fact that granular resistors have negative coefficients of resistivity gives the gran-annular furnace two distinct advantages over wirewound furnaces. In both types the hottest part of the heating chamber is somewhere near the middle as a result of the greater heat radiation at the ends.[4] In the wire type, since the resistance of the wire is the greatest where the temperature is the highest, more calories of heat will be liberated per unit of length in the middle of the furnace than in any other part. Therefore, the most heat is liberated where it is least desired, thus increasing the difference in temperature between the middle and adjacent parts.

In the gran-annular furnace the hottest part has the least resistance and hence less heat is generated in the middle than at any other part of the heating chamber. In fact, there is an absolutely automatic adjustment tending to make the temperature uniform throughout the entire length of the resistor column.

The other advantage is the automatic regulation in

[3] Read Electrochemical and Metallurgical Industry, Vol. I, pp. 481-482.
[3] Northrup, Metallurgical and Chemical Engineering, May, 1913.
[4] Electric Furnaces in the Iron and Steel Industry, Vom Baur, page 86.

starting the furnace. A furnace should be heated in about equal temperature intervals. A given number of watts will raise the temperature of a cold furnace several times as many degrees as will an increase of the same number of watts 1000 or 1200 degrees higher. The wattage should be progressively increased while heating. A wire furnace has its least resistance when cold and demands changing the external resistance while heating. The gran-annular furnace, having its greatest resistance when cold, can be started with a given external resistance (which will be considerably less than the resistance of the furnace) and as the temperature increases the wattage increases, due to the furnace resistance approaching the external resistance.

Operation and Control of Temperature

The furnace can be used with either direct or alternating current. Where the latter is available any of the above-named resistors can be used, carbon and graphite demanding lower voltages than kryptol. A furnace having dimensions as given in Fig. 1 requires a pressure of 110 to 115 volts when kryptol is used. Since nearly all laboratories have alternating or direct current at this pressure, the use of lower voltages will not be discussed further. When direct current is used the Weston miniature precision ammeters and voltmeters are entirely satisfactory for watt measurements.

For the proper control of temperature, C. H. Fulton and the writer have designed a special rheostat. It consists of nineteen coils of resistance wire, each of which is connected to a separate single-throw switch. The first coil has a resistance of 6 ohms and a carrying capacity of 18 amperes, the reason for which will appear later. The second coil has a resistance (102 ohms) such that when connected in parallel with the first coil, their combined resistance is 5 2/3 ohms.

In this way the addition of each coil in parallel lowers the resistance 1/3 ohm, and adds as much carrying capacity as will result from the decreased resistance, until 1 ohm is reached, when each additional coil decreases the resistance ¼ ohm. Thus, when all of the coils are used at the same time, they have a resistance of ¼ ohm and a carrying capacity of 50 amperes.

A 50-amp. single-throw switch, used for short-circuiting the furnace, is also provided on the same switchboard. A current of 50 amperes is seldom needed, so the excess carrying capacity permits the cutting out of some of the intermediate coils to obtain small differences in resistance. For instance, when the first thirteen coils are in, the resistance is 2 ohms. The actual resistance of the second coil is 102 ohms and by disconnecting it the resistance of the twelve remaining coils becomes 2.04 ohms. Now, if the third coil, having a resistance of 91 ohms, be disconnected, the resistance of the remaining coils becomes 2.09 ohms.

In operating both granular-resistor and wire furnaces and in designing rheostats for same, this fact should be taken into consideration: that with a given external resistance, the watts consumed in the furnace becomes a maximum when its resistance is equal to the external resistance. If a furnace has a resistance, when cold, of 6 ohms and an external resistance of 4 ohms be used and the pressure is 110 volts, there will be 726 watts consumed in the furnace. As the temperature of the resistor increases its resistance decreases quite rapidly so that when the resistance of the furnace reaches 4 ohms it is receiving 757 watts, decreasing to 740 watts when a furnace resistance of 3 ohms is reached.

In taking critical points with a thermo-couple under these conditions a slight change in the heating rate may be noticed when the furnace resistance just equals the external resistance, which is due to the furnace and not to the sample under investigation. If current is used when cooling another point shows itself. These points, however, are only detectable when a potentiometer is used to measure the voltage of the thermo-couple.

The maximum resistance of the rheostat is obtained as follows: Having decided that 500 watts will be the minimum required (see Fig. 3) at any time, and remembering that the most unfavorable condition for a minimum, i.e., the most favorable for a maximum, is when the furnace resistance equals the external resistance, we assume this condition and solve for the latter. Let R equal the resistance sought and assume the voltage as 110. Then

$$\frac{110}{2\,R} = \text{Current flowing},$$

and

$$\left(\frac{110}{2\,R}\right)^2 R = 500 \text{ watts}.$$

Whence R = 6.05 ohms.

When using the maximum resistance of the rheostat (6 ohms), we find that 504 watts is the most that the furnace can possibly receive.

Uses

The atmosphere of the furnace above 1200 degrees C. analyzes as follows: Oxygen, 0.20%; nitrogen, 68.90%; carbon dioxide, 0.70%, and carbon monoxide,

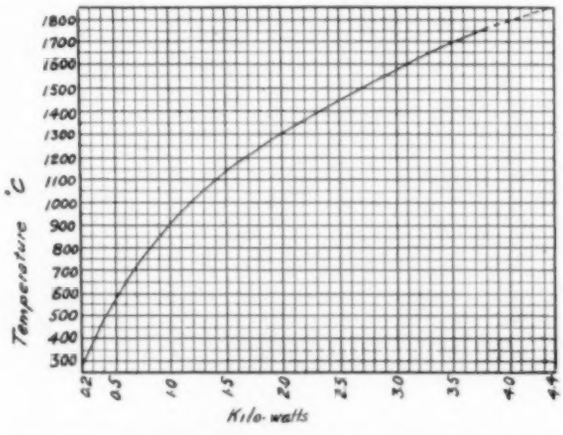


FIG. 3—KILOWATT-TEMPERATURE CURVE FOR GRAN-ANNULAR FURNACE

30.20%. If a different atmosphere is desired, gas may be admitted through a hole leading from the bottom of the furnace into the heating chamber. If an oxidizing atmosphere is desired all that is necessary is to leave the hole open and provide an opening at the top of the furnace and a strong current of air flows through the heating chamber.

C. H. Fulton uses a gran-annular furnace, among other things, to make seger cone melting point determinations. The cones can be watched through a hole in the furnace cover, and good determinations be made at very high temperatures. His work with slags has already been mentioned.

F. A. Fahrenwald, doing research work for the National Dental Association, is using a gran-annular furnace. He uses it largely for melting metals, for the purpose of forming alloys, and the remarkable manner in which the furnace stands the severe usage deserves mention. It has been heated as many as twenty times in eight hours to a temperature of 1500 degrees C., the heating rate being so fast that that temperature was reached in less than fifteen minutes. In one instance the furnace was heated from room temperature to a white heat in eight minutes.

The writer is using one of the furnaces to find the critical points of alloys in a binary system. Some of the points are so slight that they cannot be detected

unless the heating or cooling rates are very slow. By using the data given in Fig. 3 the thermal rate may be controlled as desired. For example, if the furnace is at a temperature of 1600 degrees C, and it is desired to locate accurately the position of critical points above 1400 degrees C., the wattage is set at 2300 and the cooling curve taken. The cooling takes about twenty minutes, while if the power is shut off the temperature drops to 1400 degrees C. in about one minute. If now the wattage be increased to 3100, a slow rate of heating will take place from 1400 up to 1600 degrees.

A temperature of 1800 degrees C. can be used with safety, as platinum has been melted in the furnace, in ounce lots, the Pt Pt-Rh couple having fused several minutes before the melt was removed. The maximum temperature of the walls of the heating chamber is limited to the fusing point of alundum (about 2050 degrees C.). It is hoped, however, that magnesia tubes will soon be available which will enable a temperature of about 2400 degrees C. to be reached.

Case School of Applied Science, Cleveland, Ohio.

Concentration of Complex Sulphide Ore from the Mary Murphy Mine

BY DYKE V. KEEDY

The article under the above caption, in the January issue of METALLURGICAL AND CHEMICAL ENGINEERING, is very interesting. It occurred to the writer that it would be worth while to apply some figures to check it up. The results are rather surprising inasmuch as they vary so widely from those given as representing the recoveries effected by the preliminary jigging, tabling and vanning operations. One lot of 3989 tons was taken as a basis, assaying as follows:

Gold	Silver	Lead	Zinc	Copper
0.25 ozs.	3.1 ozs.	5.4%	8.7%	0.6%

The recoveries are claimed to have been:

Gold	Silver	Lead	Zinc	Copper
75.9%	50.6%	86.7%	58.6%	55%

From this lot of ore it is said there was obtained the following products assaying:

	Wt., Tons	Gold, Ozs.	Silver, Ozs.	Lead, %	Zinc, %	Copper, %
Lead Concentrates	138	2.26	12.4	48.8	10.8	0.7
Zinc-Iron Middlings	273	0.32	7.0	7.2	38.1	2.3
Zinc Slime	34	0.19	7.1	9.6	30.9	1.5
Tailing	3544	0.07	1.7	1.4	4.0	0.3
	3989					

On page 25 of the report it will be noted that the recoveries were calculated by deducting the metallic content of the tailings from that of the heads and counting the difference as recoveries made in the concentrating department; even so, the figures as given are slightly incorrect, the actual figures being:

Heads, 3989 Tons Actually Contained	Tailings, 3544 Tons Said to Contain	Recoveries as by Difference
Gold..... 997.25 ozs.	Gold.....208.18 ozs.	Gold.....75.14%
Silver....1236.59 ozs.	Silver.....602.48 ozs.	Silver.....52.27%
Lead..... 215.406 tons	Lead..... 49.616 tons	Lead.....76.98%
Zinc..... 347.043 tons	Zinc.....141.760 tons	Zinc.....59.16%
Copper... 23.934 tons	Copper.... 10.632 tons	Copper.....55.57%

These figures check pretty closely with those given in the report, except in the lead, but they should check exactly since they were presumably arrived at from the same starting point and by the same method of calculating.

This method of calculating recoveries is incorrect and misleading because of the very important fact that the large quantity of water used on the jiggs and tables and running to waste therefrom carries unseen and frequently unnoticed an unknown quantity of mineral values.

Rarely, if ever, are there any practical means at hand whereby this water can be caught and its burden of mineral values accurately determined, and since it is therefore practically impossible to catch and accurately sample the tailings, the only true and dependable method to pursue is from the other end of the operations, namely, counting, as being recovered, only the values carried in the concentrates and the balance as lost.

Figuring on this basis, we calculate the recoveries and distribute the percentage of the various values in the various products as per the following tables:

GOLD

TABLE "A"

SHOWING DISTRIBUTION OF VALUES

3989 tons of ore at 0.25 oz. = 997.25 oz.									
Lead Concentrates....	138	tons at	2.26 oz.	=	311.88 oz.	=	31.27%	of tota	go
Zinc-Iron Middlings...	273	"	" 0.32	"	= 87.36	"	= 8.76%	"	" "
Zinc Slimes.....	34	"	" 0.19	"	= 6.46	"	= .65%	"	" "
Amalgam.....					=319.70	"	= 32.08%	"	" "
Tailings.....3544		"	" 0.076	"	=271.85	"	= 27.24%	"	" "
3989		"	" 0.25	"	=997.25	"	=100%	"	" "

Only the gold which reported itself in the amalgam and in the carpet, 32.08 per cent, and in the lead concentrate 31.27 per cent, total 63.55 per cent, can be dependably counted as saved. A portion, possibly 65 per cent or 70 per cent, of the gold carried in the zinc-iron middlings, 8.76 per cent, and in the zinc slime, 0.65 per cent, total 9.41 per cent, may also be saved, which would then bring the ultimate gold recovery up to about 70 per cent.

SILVER

TABLE "B"

SHOWING DISTRIBUTION OF VALUES

3989 tons of ore at 3.1 Oz. = 12,365.9 Oz. Silver									
Lead Concentrates....	138	tons at	12.4 oz.	=	1711.2 oz.	=	13.84%	of tot.	silv.
Zinc-Iron Middlings...	273	"	" 7.0	"	= 1911.0	"	= 15.45%	"	" "
Zinc Slimes.....	34	"	" 7.1	"	= 241.4	"	= 1.95%	"	" "
Tailings.....3544		"	" 2.4	"	= 8502.3	"	= 68.76%	"	" "
3989		"	" 3.1	"	=12365.9	"	=100%	"	" "

On the assumption that the waste waters from the jiggs, tables and vanners did not carry away any values whatever, which, of course, is not true, and provided the sampling and assaying of the tailings truly represented actual facts, then the tailings would have carried only 1.7 ozs. per ton or 48.71 per cent of the total silver. But by these calculations we find the tailings, including the losses in the wash water, actually carried 2.4 ozs., or 68,76 per cent of the total silver; less that which was caught on the amalgam plates and carpets. No weights having been given in the report respecting the quantity of silver thus recovered, makes it impossible to calculate the ultimate recovery.

LEAD

TABLE "C"

SHOWING DISTRIBUTION OF VALUES

3989 tons of ore at 5.4% = 215.406 tons lead									
Lead Concentrates..	138	tons at	48.8%	=	67.344 tons	=	31.26%	of tot.	lead
Zinc-Iron Middlings.	273	"	" 7.2%	=	19.656	"	= 9.13%	"	" "
Zinc Slime.....	34	"	" 9.6%	=	3.264	"	= 1.51%	"	" "
Tailings.....3544		"	" 3.53%	=	1251.42	"	= 58.10%	"	" "
3989		"	" 5.4%	=	215.406	"	=100%	"	" "

These calculations are made from the heads and the three weighed and sampled products, only one of which, however, at this stage of the operations, is marketable; the other two are to be further treated. The sampling of the tailings, as given in the report, 1.4 per cent, is fairly to be questioned, for reasons before stated. The lead not reporting in the lead concentrates, or in products yet to be treated, must be counted as lost. It is shown that 58.10 per cent of the total lead had passed into the tailings and was lost at this stage of the operations, leaving 41.90 as a possible ultimate recovery, even if supposing that a perfect separation of the lead will be made from the zinc-iron middlings and zinc slimes. We

cannot find any way to justify the claim, made in the report, of a recovery of 86.7 per cent, but rather it looks as if some figure between 35 per cent and 40 per cent would be the maximum.

ZINC

TABLE "D"

SHOWING DISTRIBUTION OF VALUES

3989 tons of ore at 8.7% = 347.043 tons of zinc							
Lead Concentrates..	138	tons at 10.8%	= 14.904 tons	=	4.29%	total zinc	
Zinc-Iron Middlings.	273	" " 38.1%	= 104.013	"	= 29.97%	"	"
Zinc Slimes.....	34	" " 30.9%	= 10.506	"	= 3.04%	"	"
Tailings.....3544		" " 6.14%	= 217.620	"	= 62.70%	"	"
3989		" " 8.7%	= 347.043	"	= 100%	"	"

In like manner as with the lead, these calculations are made from the heads and the three weighed and sampled products, the tailings being calculated by difference; this for the reasons as stated before. It would be obviously unfair and misleading to make calculations upon recoveries that clearly were not made. The zinc reporting in the lead concentrates is worse than lost, as its presence in that product induces a penalty. Inasmuch as 62.70 per cent of the zinc is lost in the tailings and 4.29 per cent in the lead concentrates, a total of 66.99, there remains only 33.01 per cent from which the ultimate recovery must be made by the slime tables and electrostatic machines. It looks as if the ultimate recovery will be even below 20 per cent. In any event it seems quite impossible to check up or account for the 58.6 per cent recovery as claimed in the report.

COPPER

TABLE "E"

SHOWING DISTRIBUTION OF VALUES

3989 tons of ore at 0.6% = 23.934 tons of copper							
Lead Concentrates..	138	tons at 0.7%	= .966 tons	=	4.04%	total copper	
Zinc-Iron Middlings.	273	" "2.3%	= 6.279	"	= 26.23%	"	"
Zinc Slime.....	34	" "1.5%	= .510	"	= 2.13%	"	"
Tailings.....3544		" "0.47%	= 16.179	"	= 67.60%	"	"
3989		" "0.6%	= 23.934	"	= 100%		

These calculations are made on the same basis as before and, of course, for the same reasons. Technically, it may be claimed that there is here shown a recovery of 32.40 per cent, inasmuch as this amount of copper reported in the so-called finished products of this department, but commercially the story is different, since the copper tenor of the lead concentrates is too low to fetch any payment therefor. The finished copper-iron products from the electrostatic machines do not run very high in copper, if on dry assay. The high tenor of zinc will induce a penalty. Were it not for the values in gold and silver these products would hardly pay to ship. At present market prices they will fetch about $20 per ton. At best there remains less than 30 per cent of the total copper, reporting in the products, subject to retreatment, from which any marketable copper product can be recovered. Upon what basis, therefore, can be made the claim of a 55 per cent recovery?

As a summary of the foregoing tables and making a comparison with the claims made in the report, wherein the Tailings are figured against the Heads and in the other case, wherein the Concentrates are figured against the Heads, we have the following:

ACCORDING TO THE REPORT	Tailings Figured Against Heads	AS HEREIN CALCULATED	Concentrates Figured Against Heads
Gold Recovered..	75.9%	Gold Recovered..	72.76%
Silver " ..	50.6%	Silver " ..	31.24%
Lead " ..	86.7%	Lead " ..	41.90%
Zinc " ..	58.6%	Zinc " ..	37.30%
Copper " ..	55.0%	Copper " ..	32.40%

We will bear in mind that these figures relate only to recoveries as meaning that we have only deducted, as losses, the values lost in the tailings. There are losses already suffered even at this stage of the operations which are just as decided losses, in fact, as those passing away in the tails, such as the Zinc reporting in the Lead Concentrates, etc. In the subsequent steps in the operations, that is, retreatment of the Zinc-Iron Middlings and Zinc slimes further losses will be suffered. The above figures representing silver recoveries will have to be modified to some extent on account of the unknown quantity of silver caught on the carpet.

ELECTRO STATIC DEPARTMENT

Had there been given any figures with respect to the weights of the products resulting from the electrostatic machines, it would be interesting to digest them to ascertain what recoveries were made. The question naturally arises as to why they were omitted as their absence is all the more noticeable since the weights were so freely given in the grinding and rough concentrating departments. The assay figures are interesting, particularly those relating to the "Retreatment of Electro Static Middlings."

For reasons given later herein, we are justified in assuming the chemist's figures to be correct and now we are prompted to ask, from whence comes all this Gold and Silver? In the table referred to, page 26, we find a Feed said to carry .52 oz. Gold and 9.1 ozs. Silver; this is presumably split into two products, viz.: Zinc product and Iron product; one carrying .56 oz. Gold and 9.8 ozs. Silver and the other .62 oz. Gold and 9.9 ozs. Silver. It might be assumed that a certain amount of a Middlings product, could also have been made, running very low in Gold and Silver and which would account for these values being so high in the other two products, but it appears from the assay figures that but little disturbance was made with the remaining chief constituents of the feed. For instance, the Lead tenor of the feed was 8.8 per cent; that of the Zinc product 11.9 per cent and that of the Iron product 8.7 per cent. It seems therefore after careful study of the assay figures, given in this table quite impossible to account for the large increase in Gold and Silver by reason of any Middlings product also being made. It looks very much as if some one has been fooling himself, unintentionally perhaps, but fooling himself just the same.

It does not seem possible that the results as shown by the tables given in the report are the very best attainable by the electrostatic machines. These fall so very far short of those that have been obtained in the treatment of similar ores that it seems more than likely that very material improvements can and will be made as soon as the machines are properly adjusted and the operatives get better acquainted with the requirements and learn how to meet them.

If and when certain obvious improvements have been made in the crushing and grinding departments (herein later discussed), an increased quantity of feed will come to the statics and in better condition for treatment. There will also be produced a less quantity of the extremely fine grades which are more difficult for the statics to handle satisfactorily. Hence in the final results a very marked improvement will be shown.

REGRINDING OF STATIC MIDDLINGS

In the absence of any figures respecting relative weights and having only the assays given, it is impossible for one to see any good net results coming from the operation of this "Retreatment of the Static Middlings," but on the contrary, it looks more as if the operations resulted in a net loss. The Lead seems to have tended to concentrate in the Zinc product, which of course results in a loss. The tenor of Zinc in the Zinc product was brought up only about 6.6 per cent or say from 28.2 per cent to 34.8 per cent while the Lead in this product increased from 10.2 per cent to 11.1 per cent also there

was an alleged increase in the Gold and Silver. A marketable Copper-Iron product was made although it yet carried 16.4 per cent Zinc which would largely offset its copper values were it not for the values in Gold and Silver which it is alleged to contain. The net results are unknown and as yet questionable.

MONNELL SLIMER

It seems hardly worth while to comment upon the results as shown, from the Monnell Slimer,—except to raise the question as to the purpose to be served by keeping it at work. We realize that it has set for it, by reason of the character of feed, a task that would be very difficult for any machine to perform with any degree of satisfaction. The results in this department will show marked improvements when proper changes have been made in the Grinding Department and yet greater improvements when the whole slime problem is approached from an entirely different angle.

REGRINDING APPARATUS

The figures given on page 24, respecting the work done by the Hardinge Mills and the Tube Mill are very interesting but their value is much enhanced when they are put in the form of percentages. The assay values of the various screen products being given, it is possible to calculate the assay of the original feed as well as that of the discharge, as a check upon the former as well as a cross check upon the chemist's work and a check also upon the one who weighed the various screen products. These figures also enable us to calculate the distribution of the values carried in the screen products, which is very important.

The way these figures check up is worthy of some comment; considering the fact that the figures representing the assay values of the Feed and Discharge were obtained by roundabout calculations which involved possible errors in taking the weights of the various screen products as well as possible errors in the chemist's figures, and concurrently bearing in mind that small errors, at the start, increase rapidly as the calculations proceed. It must be noted that the final figures check up very closely. This indicates an uncommon degree of accuracy in the chemist's figures and warrants confidence being placed in them.

The figures given in the report respecting the assays and weights of the various screen products resulting from the screen analyses of the various feeds and discharges to and from the Hardinge mills are herein tabulated in the form of percentages by weight and so as to clearly reveal the distribution of values in all the various screen products, as follows:

TABLE I

No. 1: Hardinge 6-Foot Mill
Feed; Oversize From Trommels, Plus Jigg Tailings

CALCULATED ASSAYS

	Gold, Ozs.	Silver, Ozs.	Lead, %	Zinc, %
Feed	.5628	2.5090	2.1447	7.4522
Discharge	.6722	2.4714	2.6036	7.4542

FEED

Grade	% by Weight	Distribution Gold, %	Distribution Silver, %	Distribution Lead, %	Distribution Zinc, %
+ 20	29.69	18.47	27.24	24.78	21.84
+ 40	30.47	30.85	24.29	17.48	22.41
+ 60	16.42	18.09	14.39	10.80	16.55
+100	10.93	18.27	14.79	10.55	16.51
+200	7.81	11.09	10.89	15.80	14.29
−200	4.68	3.23	8.40	20.59	8.41
	100	100	100	100	100

DISCHARGE

Grade	% by Weight	Distribution Gold, %	Distribution Silver, %	Distribution Lead, %	Distribution Zinc, %
+ 40	11.76	13.98	10.95	4.24	6.24
+ 60	21.01	18.45	14.45	9.11	13.58
+100	21.85	22.76	21.22	14.28	21.13
+200	21.85	22.42	23.87	23.75	28.58
−200	23.53	22.39	29.51	48.62	30.47
	100	100	100	100	100

TABLE II

No. 2; Hardinge 6-Foot Mill
Feed; Jigg Tailings

CALCULATED ASSAYS

	Gold, Ozs.	Silver, Ozs.	Lead, %	Zinc, %
Feed	.3736	2.9506	2.0039	9.3154
Discharge	.4142	2.7604	1.9664	8.6946

FEED

Grade	% by Weight	Distribution Gold, %	Distribution Silver, %	Distribution Lead, %	Distribution Zinc, %
+ 20	56.31	63.30	49.63	55.67	36.84
+ 40	15.54	10.81	14.56	13.28	14.93
+ 60	6.80	8.57	9.46	7.37	10.53
+100	7.75	9.18	9.97	7.00	13.32
+200	9.72	5.97	10.21	6.54	13.85
−200	3.88	2.17	6.17	10.14	10.53
	100	100	100	100	100

DISCHARGE

Grade	% by Weight	Distribution Gold, %	Distribution Silver, %	Distribution Lead, %	Distribution Zinc, %
+ 40	16.66	16.90	13.19	9.57	7.36
+ 60	14.60	18.32	11.63	7.70	9.33
+100	16.66	18.91	15.07	11.19	16.15
+200	21.87	26.92	20.61	14.68	27.88
−200	30.21	18.95	39.50	56.86	39.28
	100	100	100	100	100

TABLE III

Tube Mill, 3½ Ft. by 16 Ft.
Feed; Coarse Table Middlings Plus Jigg Tailings

CALCULATED ASSAYS

	Gold, Ozs.	Silver, Ozs.	Lead, %	Zinc, %
Feed	.2429	2.8242	1.8149	7.9656
Discharge	.2194	2.5469	2.1163	9.7766

FEED

Grade	% by Weight	Distribution Gold, %	Distribution Silver, %	Distribution Lead, %	Distribution Zinc, %
+ 20	60.18	57.02	59.66	53.06	35.34
+ 40	14.10	15.08	11.56	11.74	13.47
+ 60	7.01	6.62	6.70	6.91	14.97
+100	8.77	12.98	10.86	9.13	22.14
+200	7.60	5.32	7.00	5.53	9.93
−200	2.34	2.98	4.22	13.63	4.15
	100	100	100	100	100

DISCHARGE

Grade	% by Weight	Distribution Gold, %	Distribution Silver, %	Distribution Lead, %	Distribution Zinc, %
+ 40	21.18	13.51	9.15	8.50	6.35
+ 60	16.47	15.01	9.06	7.32	1.53
+100	23.53	31.11	29.79	18.90	35.82
+200	23.53	25.74	29.79	23.02	35.00
−200	15.29	14.63	22.21	42.26	21.30
	100	100	100	100	100

TABLE IV

Hardinge 4-Foot Mill
Feed; Jigg Middlings

CALCULATED ASSAYS

	Gold, Ozs.	Silver, Ozs.	Lead, %	Zinc, %
Feed	.4785	5.3377	1.5235	2.6038
Discharge	.8936	6.4241	.9141	2.4807

FEED

Grade	% by Weight	Distribution Gold, %	Distribution Silver, %	Distribution Lead, %	Distribution Zinc, %
+ 20	46.34	58.10	45.16	52.33	59.05
+ 40	12.20	16.32	13.02	12.80	15.17
+ 60	7.32	5.52	6.16	9.00	6.42
+100	8.54	5.71	6.88	4.60	5.76
+200	14.63	7.94	16.45	9.39	8.42
−200	10.97	6.41	12.33	11.88	5.18
	100	100	100	100	100

DISCHARGE

Grade	% by Weight	Distribution Gold, %	Distribution Silver, %	Distribution Lead, %	Distribution Zinc, %
+ 60	2.44	Not enough for assay		2.00	2.30
+100	12.19	13.64	17.08	7.60	11.05
+200	34.15	47.38	28.70	41.09	36.49
−200	51.22	38.98	54.22	49.31	50.16
	100	100	100	100	100

There appears nowhere in the report any information respecting the degree of fineness to which the ore must be crushed in order to free the greater part of the various mineral values. This knowledge is of the utmost importance to one who has in hand the task of recovering values in any ore and particularly one like this under discussion. One may find some warrant in assuming that this ore is being, in the very first stages, too finely ground, from the fact that the statement is made that a certain amount of tailings is rejected from the table treating the coarsest grade of minus 1 mm feed. We may therefore for the moment assume that ore 0.0122 in., is fine enough to free such a large percentage of the minerals as to produce, in the concentrating department, not too great a proportion of

middlings. On this assumption let us see what has been done in the grinding mills; taking each one of the four tables of figures separately and finding the percentage, by weight, of the material that is coarser than 60 and comparing it with that which is finer and concurrently comparing distribution of values; thus, in this manner, finding out how much unnecessary and really undesirable and actually harmful work is being done in the grinding mills. Any quantity of ore being ground beyond the degree of fineness necessary to free the respective minerals is decidedly harmful, always.

TABLE I-A

FEED

Grade	% by Weight	Distribution Gold, %	Distribution Silver, %	Distribution Lead, %	Distribution Zinc, %
+60	76.58	67.41	65.92	53.06	60.80
−60	23.42	32.59	34.08	46.94	39.20
	100	100	100	100	100

DISCHARGE

Grade	% by Weight	Distribution Gold, %	Distribution Silver, %	Distribution Lead, %	Distribution Zinc, %
+60	32.77	32.43	25.40	13.35	19.82
−60	67.23	67.57	74.60	86.65	80.18
	100	100	100	100	100

TABLE II-B

FEED

Grade	% by Weight	Distribution Gold, %	Distribution Silver, %	Distribution Lead, %	Distribution Zinc, %
W60	78.65	82.68	73.65	76.32	62.30
W60	21.35	17.32	26.35	23.68	27.30
	100	100	100	100	100

DISCHARGE

Grade	% by Weight	Distribution Gold, %	Distribution Silver, %	Distribution Lead, %	Distribution Zinc, %
+60	31.26	35.22	24.82	17.27	16.69
−60	68.74	64.78	75.18	82.73	83.31
	100	100	100	100	100

TABLE III-C

FEED

Grade	% by Weight	Distribution Gold, %	Distribution Silver, %	Distribution Lead, %	Distribution Zinc, %
+60	81.29	78.72	77.92	71.71	63.78
−60	18.71	21.28	22.08	28.29	36.22
	100	100	100	100	100

DISCHARGE

Grade	% by Weight	Distribution Gold, %	Distribution Silver, %	Distribution Lead, %	Distribution Zinc, %
+60	37.65	28.52	18.21	15.82	7.88
−60	62.35	71.48	81.79	84.19	92.12
	100	100	100	100	100

TABLE IV-D

FEED

Grade	% by Weight	Distribution Gold, %	Distribution Silver, %	Distribution Lead, %	Distribution Zinc, %
+60	65.86	79.94	64.34	74.13	80.64
−60	34.14	20.06	35.66	25.87	19.36
	100	100	100	100	100

DISCHARGE

Grade	% by Weight	Distribution Gold, %	Distribution Silver, %	Distribution Lead, %	Distribution Zinc, %
+60	2.44	Not enough for assay		2.00	2.30
−60	97.56	100	100	98.00	97.70
	100	100	100	100	100

It will be seen at once that in every instance much of the feed going to the grinding mills is already fine enough; this being true, why should it be further punished by passing through the slaughter house? In detail we see in the Feed in Table I A 23.42 per cent minus 60 mesh; in Table II B 21.35 per cent; in Table III C 18.71 per cent and in Table IV D 34.14 per cent. The immediate effect of passing this fine material through the mills is to largely increase the already too high percentage of slimes. In practice it might be found desirable to classify at as coarse a grade as 50 mesh; say 0.0146 in. instead of 60 mesh 0.0122 in., or at some point in between, or it may be found that even a coarser grade would be desirable.

The work done, as represented by Table I A is particularly bad, inasmuch as the 23.42 per cent by weight, of the FEED carries, in the minus 60 mesh grade, 46.94 per cent of the total Lead content; while in the DISCHARGE we find, in the same grade, 67.23 per cent by weight, carrying 86.65 per cent of the total Lead content; and of this 86.65 per cent of Lead 48.62 per cent has already been crushed to pass a 200 mesh screen; much of this, no doubt, is almost as fine as pigment and on this account it is extremely difficult, if not impossible to recover its Lead and other values. All the other tables could be discussed in the same manner and the same general conditions found to exist.

We have no information with respect to the relative tonnage of feed going to the pebble mills, respectively, for then it would be well worth while to ascertain, definitely, what percentage of the total values in the ore is ground finer than 200 mesh. But since the percentages, by weight, of all the screen products passing to and from the machines and their assay values have been thrown into percentage tables to show the distribution of values, it might be well to note the following:

Table	I.	Minus	200,	carries	48.62%	Total	Lead	and	30.47%	Total	Zinc
"	II.	"	200,	"	56.86%	"	"	"	39.28%	"	"
"	III.	"	200,	"	42.26%	"	"	"	21.30%	"	"
"	IV.	"	200,	"	49.31%	"	"	"	50.16%	"	"

It will be readily seen by reference to the tables that fully 1/3 of the minus 200 mesh, reporting in the DISCHARGE was not made in the pebble mills, but was passed in as feed when it was already fine enough to pass a 200 mesh screen. It is fair to assume that this minus 200 mesh feed which passed into the machine was therein ground still finer. It appears therefore that so far as this part of the work is concerned, the practice carried on in the grinding department would be much better suited for a paint works than for a concentrating mill.

This digest of the work, done in the grinding department, clearly indicates that not far from 50 per cent of all the Lead carried in the jigg tailings and middlings was ground fine enough to pass a 200 mesh screen and much of this 50 per cent was ground to a degree of fineness closely approaching that of pigment. This in itself goes a long way to show the reason why there was made, in the operations, such low percentages of final recovery.

If and when necessary changes and adjustments have been made looking towards a radical reduction of the percentage of fines and slime produced, and when a minimum has been reached, there is no reason why a satisfactory recovery of their contained values cannot be made, provided they are carefully and properly classified and passed over a good slime table.

In this connection it may be said that last summer while making some tests for the purpose of deciding upon the best way to treat fines and slimes of this character and to make a selection of the best slime table to use for the purpose, we had a quantity of "tankage" carrying values in Zinc and Lead, all of which was fine enough to pass a 200 mesh screen. This was passed through an improved classifier, which had then lately been designed and put on the market. The objective point was to wash away nothing but the true slime or colloidal matter, which was sent to waste as being unamenable to further mechanical treatment. From the oversize, or underflow, there was made a Lead product, carrying 77 per cent Lead, every bit of which would pass a DuFour silk cloth screen of 275 mesh; and a Zinc product carrying 51 per cent Zinc. This is only mentioned to show what can be done with a minus 200 mesh product, only provided it has not previously been pulverized to actual slime, and provided it is properly classified, and a suitable slime table used to further treat it.

On Page 23, of the report, there appears a remark to the effect that "while the work of the Hardinge Mills is satisfactory with respect to grinding Tailings, they

have not done so well in the work of grinding Middlings, on account of producing too much mineral slime." There is very substantial ground upon which to base a belief that the fault has not been so much with the Hardinge Mill itself, as with the way these machines have been handled and the character of the feed passing to them. Refer for instance to

TABLE No. 4; Four foot Hardinge Mill, grinding Jigg Middlings. Observe that 34.14 per cent, by weight, of the FEED was already finer than 60 mesh; and 10.97 per cent was minus 200 mesh; while in the DISCHARGE 97.56 per cent was finer than 70 mesh and 51.22 per cent was finer than 200. This 34.14 per cent, by weight, of the FEED, finer than 60 mesh, should probably have bypassed the Hardinge, and certainly so, provided the greater part of it consisted of free mineral particles; but at any rate, the 10.97 per cent by weight, which was finer than 200 mesh, should have bypassed. The remaining 65.86 per cent (plus 60 mesh) or at most, the 74.40 per cent (plus 100 mesh) should have been passed through the Hardinge rapidly, in the effort to grind it only fine enough to pass a 60 or a 100 mesh screen, as the case might be, but surely not to so severely pulverize it. The oversize to be returned to the Hardinge, after classification.

It must be borne in mind that the efficiency of Rolls falls away alarmingly when they are put to the work of such fine grinding as is necessary in this case. The wisdom of making the proposed change from Hardinge Mills to Rolls is therefore very much to be questioned.

There are several well known ways to regulate the performances of the Hardinge Mills, so as to make the results conform pretty fairly well with current requirements.

In treating an ore like the one under discussion, and in which the mineral constituents are very friable and strongly tend to break down into slimes, grinding operations should be carried on with these features and conditions kept well in mind. It certainly is necessary to classify the feed, so as to deliver to the mill no material that has already been ground fine enough to physically free the mineral particles. It is equally necessary to classify the discharge and to return the oversize. When this practice is carried on and when proper adjustments have been made, it will be found that there will be a very marked decrease in the quantity of true slimes that is produced.

After a careful study of the report, as published, and the digest of the same as given herein, we believe it will be seen that by making some changes in the grinding department looking towards a system of step grinding for the purpose of effecting a gradual fine granulation of the ore particles, as opposed to a too sudden and violent pulverization, a great improvement can be made over the indifferent recoveries that it will be seen are now being effected. To the proposed changes to be made in the Grinding Department there could also, to good advantage, be added a certain number of classifiers, located at various points in the system to enable the ore to bypass the grinding department as soon as it has reached the degree of fineness necessary to free the mineral particles; letting the jigg and table work be such, as to pass for regrinding, substantially, only such middlings as are true Middlings (attached particles) and to inaugurate a better system of treating the fines and slimes after they have been radically reduced in quantity.

6 Beacon St., Boston, Mass.

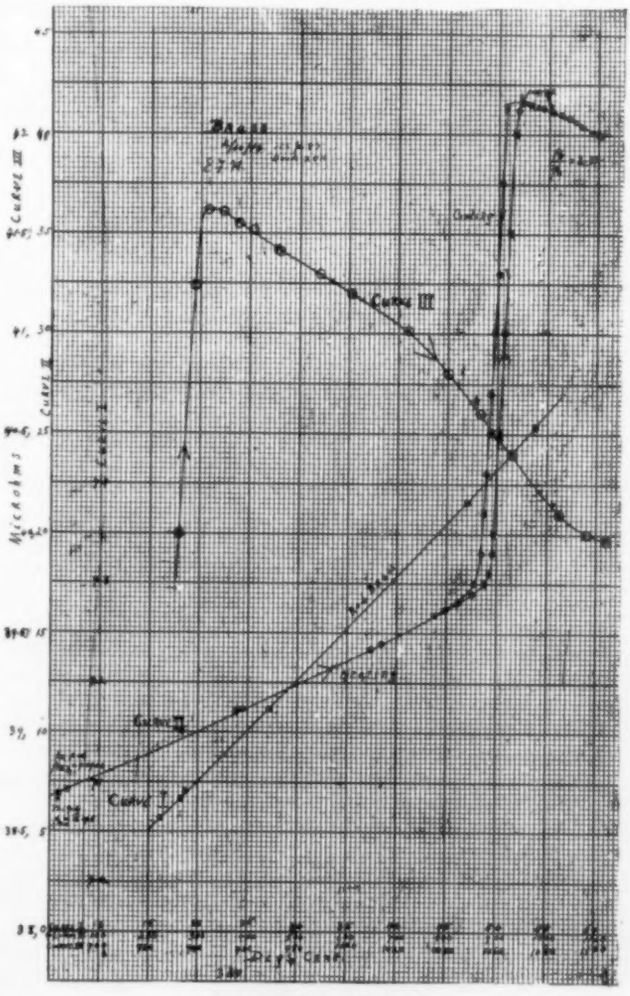
A submarine oxyhydrogen torch is reported to have been tested in Kiel harbor, Germany, for the purpose of testing the possibility of dismantling sunken vessels. A 4-inch iron case was cut in half a minute.

Resistivity of Brass; Solid and Molten

BY EDWIN F. NORTHRUP

It has been pointed out to the writer that, in designing certain types of electric furnaces for the treatment of molten brass, an accurate knowledge of the electrical resistivity of this alloy in the molten state would be useful. As both the method and equipment for making this determination were available, the writer decided to measure in both the solid and liquid state the resistivity of ordinary rod brass and publish the data for the benefit of any one who might find it useful.

Alloys, which pass under the name of brass, are of very variable composition and a complete specification of the particular alloy for which data were obtained would require the making of an accurate chemical analysis. This the writer did not feel justified in undertaking.[1] The brass used in the measurement was the ordi-



RESISTIVITY CURVES

nary rod brass, in rods about 0.3 cm in diameter, commonly used in the machine shop. Its quality is, to a certain extent, determined by a knowledge of its density. The density of the rod brass was, therefore, determined by a measurement of the mass and the volume of a rod about 91 cm long, and found to equal 8.472. Its specific resistance while in the form of a rod was also determined with precision in the temperature range 16.25° C. to 53.70° C. Curve I and the table record the results obtained. With this much exact

[1] After this article had been put into print, an analysis was made by courtesies of the Ajax Metal Company, with the knowledge and consent of Dr. Northrup, of pieces of the same lot of brass used in his determinations, and it was found to contain 63% copper, 34.58% zinc, 2.42% lead, and traces of tin and iron.—Carl Hering.

information, respecting the nature of the brass used in the measurements, it is thought that the data obtained apply to a material of sufficiently definite composition to meet engineering requirements, and to serve the designer with information sufficiently precise for his purposes.

The method of measurement employed for measuring the resistivity of the brass from a temperature at which it was molten down to room temperature, and again from room temperature up to 1104° C., was in all essential respects the same as that employed by the writer in measuring the "Resistivity of Copper in Temperature Range 20° C. to 1450° C." published in the *Journal* of the Franklin Institute, January, 1914. The furnace employed in measuring brass and all other materials to a temperature of 1600° C. or more has already been described in METALLURGICAL AND CHEMICAL ENGINEERING, January, 1914.

Considerable precaution must be exercised in measuring an alloy like brass, one of the constituents of which has a low vaporization temperature. Thus the vaporization temperature of zinc is given as 918° C. If the brass is raised, therefore, to a temperature at which the zinc volatilizes, not only is the composition of the brass altered in the course of the measurement, but the measurement is interfered with by the vapor of zinc (which being in a CO atmosphere does not oxidize) congealing on the under surface of the furnace cover, thus short-circuiting the molybdenum wire terminals employed.

The first time the measurement was attempted these results were not foreseen and the furnace was brought to a temperature of a little over 1200° C. before the container was filled with brass. The result was that a goodly proportion of the zinc distilled out of the brass and deposited a thick layer of metallic beads on the lower surface of the furnace cover. Fortunately the construction of the furnace is such that no injury happened to the furnace.

After this experience the container was heated before filling with brass to a temperature of only 1020° C., and immediately allowed to cool, readings of temperature and resistivity being taken as the cooling proceeded (see curve II). After the container had cooled to 19.4° C. the resistivity was measured again with rising temperature and the temperature was carried this time to 1104° C. (See curves II and III). The agreement at 972° C. between the cooling and the heating curves, at which temperature the brass is molten, was exact. At 940° C. the difference between heating and cooling resistivity is 0.42 per cent.

After the measurement was over it was found that a very small amount of zinc had distilled out of the brass, the maximum temperature reached being, as above stated, 1104° C. Since pure zinc is said to vaporize at 918° C. it follows that when zinc is alloyed with copper the vaporization of zinc occurs at a higher temperature. The vaporization appears to be inappreciable until a temperature of nearly 1090° C. is reached. Since the resistivity is very sensitive to changes in the composition of the material, and since the writer has now so perfected the method of measuring the resistivity of a molten metal or alloy that the error need not exceed 0.1 of one per cent. determinations of resistivity might be employed with advantage for determining alterations in composition of alloys due to vaporization or other causes.

Referring now to the curves we invite attention to the following points: The resistivity of the rod brass is 7.101 microhms per centimeter cube at 20° C. and 7.550 microhms at 50° C. This gives as the coefficient of rod brass, reckoning from 20° C., 0.0021. Thus brass increases in resistance with raise of temperature about one-half as fast as copper in the solid state. The increase is not quite linear, curve I being very slightly convex toward the temperature axis.

The resistivity of the brass which had been cooled from the molten state in the container measured 6.957 microhms at 20° C. It was probably somewhat less than this, because the brass in cooling in the container from the molten state must suffer some shrinkage and the measurement gives the volume and not the mass resistivity of the brass. We conclude, therefore, that the resistivity of brass which has been slowly cooled from the molten state is at least 2 per cent less at 20° C. than the resistivity of the same brass when drawn into a rod. The ratio of the resistivity of the brass just after fusion is complete, to the resistivity just before fusion starts, is 2.37+. This is a very large increase in resistivity in passing from the solid to the molten state and is about 18 per cent greater than in the case of many of the pure metals.

The change in the resistivity with increase in temperature in the molten state is plotted on an enlarged scale in curve III. It is interesting to note that the resistivity *decreases* with increase in temperature. The writer has shown in a joint article by E. F. Northrup and V. A. Suydam, *Journal* of the Franklin Institute, February, 1913, that zinc has a strongly negative temperature coefficient in the molten state up to a temperature of 750° C. This constituent of the brass apparently determines the slope of the curve in the molten state. The fact that curve III begins to show an inflection at about 1090° C., the decrease in the resistivity becoming less rapid, indicates that it is at about this temperature that the brass begins to lose some of its zinc by vaporization. If all the zinc were to vaporize out the curve would become like that for copper, which shows a strongly positive coefficient at all temperatures up to the highest measured, which was 1450° C.

TABLE I.

Temp. Degs. C.	Microhms per cm cube	Ratio of resistivity at two temps.		Notes
20...	7.101....	ρ_{1000}	= 5.922	Rod brass
		ρ_{20}		Density = 8.472
20...	6.957....	ρ liquid / ρ solid	= 2.37+	Cooled slowly from molten state
50...	7.55			Rod brass
944...	41.61			Heated slowly from solid state
1000...	41.20			Heated slowly from solid state
1084...	40.11			Heated slowly from solid state

The writer in measuring the resistivity of the pure metals confirmed all his results by making each measurement twice, each time in a different container. The above measurements on brass were only made once, as the variable composition of this material is such that there would be no justification for the expenditure of a large amount of time to obtain very high accuracies. However, the writer believes that the data given in curve I may be relied upon to within 0.2 of one per cent and that in curve III to within 0.5 of one per cent.

The examination of the resistivity curves of the alloys is now, certainly, a matter of routine, if one is provided with a suitable equipment, and the writer believes that these curves would give very considerable information to metallurgists respecting the properties and the behavior of alloys. He hopes to see, in the near future, many measurements of the above character made and published.

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The Chinese iron and steel trade has been upset by revolutionary disturbances during the past two years. Both imports and exports of iron and steel products fell off remarkably in 1912 as compared with 1911, and the 1913 business has not returned to normal. A new 300-ton blast furnace is in course of construction at Hanyang, and another at Tayeh.

Industrial Synthetic Production of Sodium Cyanide*

BY CAMILLE MATIGNON

Among the nitrogen compounds nitric acid, ammonia, and cyanide, the last one is only of secondary or minor industrial importance as compared with the other two. Chile supplies the world annually with 2,500,000 tons of sodium nitrate; the manufacture of gas and coke for metallurgical purposes furnishes the market with 1,000,000 tons of ammonium sulphate; the cyanide industry, on the other hand, is limited annually to from 20,000 tons to 25,000 tons of cyanide compounds, in the form of sodium and potassium cyanide, ferrous and ferric cyanide and Prussian blue.

The use of cyanides has increased particularly since the introduction of the Arthur and Forrest process of gold extraction in the year 1888. Before that time the annual production of cyanide of potassium, which was the only alkali cyanide then in use, did not exceed 100 tons; it reached 450 tons in 1888; from then on it increased annually by about 1000 tons of potassium cyanide and sodium cyanide, the latter having been introduced into the market in the meantime. Almost the whole quantity of alkali cyanides is used for the gold extraction process; the gold and silver plating industry consume only an inconsiderable amount of cyanides.

As said before, the cyanide compounds are only of secondary importance as to quantity in the industry of nitrogen compounds. On the other hand, as to price the nitrogen of the cyanide is much more valuable than nitrate nitrogen or ammonia nitrogen. The value of these latter two does not exceed 13.6 cents per pound, while the price of cyanide nitrogen reaches and exceeds 54 cents per pound. Under such conditions it should be worth while to convert nitric acid or ammonia into cyanide.

There are several reactions by which these transformations can be achieved. None of them has been made use of practically for transforming sodium nitrate into sodium cyanide, while ammonia is actually used for the manufacture of cyanides. The inverse reaction is much more easily carried out; cyanide produces easily ammonia when heated in a current of steam. Hydrocyanic acid, which is the nitrite of formic acid, has a tendency to decompose into ammonia and formic acid, and the salts of hydrocyanic acid give ammonia and formates. The formates are decomposed at red heat and only alkali carbonate remains when sodium cyanide is heated. $2\,CN\,Na + 4\,H_2O = 2\,NH_3 + Na_2CO_3 + CO + H$.

A great number of research chemists are occupied at the present time with the industrial problem of the synthesis of ammonia by way of the cyanides. This seems to me to be illogical, for hydrocyanic acid is a substance which when produced from its elements absorbs heat:

$$C + N + H = CNH - 30.5 \text{ cal.}$$

and it will always be more expensive than ammonia, the heat of formation of which is exothermic:

$$N + 3\,H = NH_3 + 12 \text{ cal}$$

The electrolytic production of sodium with melted sodium hydroxide as electrolyte has put us into a position to produce sodium very cheaply. Starting from sodium and from ammonia, a process has been elaborated which supplies the metallurgy of gold with a considerable amount of the cyanide it needs.

The English factory of Castner is intimately connected with the history of sodium and there the preparation of sodium, and subsequently that of cyanide, was first studied; but only with the improvements introduced by the Deutsche Gold und Silberscheide Anstalt of Frankfurt did the manufacture of cyanide become an industrial process.

On examining the formula of sodium cyanide CN Na (N = 14 and Na = 23) it will be seen that 1 lb. of cyanide nitrogen requires 1 lb. of ammonia nitrogen and about 2 lbs. of sodium. Taking 13.6 cents as the price of 1 lb. of ammonia nitrogen, and 54.4 cents as the value of 1 lb. of cyanide nitrogen, there remains a difference of 40.8 cents to cover the cost of 2 lbs. of sodium plus the cost of transformation and profit. As the electrolytic process of Castner with cheap electric power can produce 1 lb. of sodium at 9.05 cents or 18.1 cents for 2 lbs. there remains finally a margin of 22.7 cents to cover the cost of manufacture and profit.

I. Original Castner Process

1. THE PRINCIPLE OF THE PROCESS.

Ammonia gas is absorbed by sodium at 400° C. with the formation of amid and the liberation of hydrogen.

$$NH_3 + Na = NH_2Na + H$$

This amid, when melted with one molecule of sodium cyanide is converted into sodium cyanamide between 550° and 600°.

$$NH_2Na + CN\,Na = CN_2Na_2 + H_2$$

Finally, this cyanamide, intimately mixed with carbon, fixes the latter at 750° to 800° with the formation of cyanide.

$$CN_2Na_2 + C = 2CNNa.$$

The molecule of cyanide which has served as intermediary, is thus recovered.

By proceeding in a different manner, the use of this intermediary molecule of cyanide can be avoided. A first carbon atom converts two molecules of amid into sodium cyanamide.

$$2NH_2Na + C = CN_2Na_2 + 2H_2.$$

Further on at 800° a second atom of carbon produces cyanide.

$$CN_2Na_2 + C = 2CNNa.$$

Castner's first idea was to produce cyanide from elementary nitrogen. When looking at the equation

$$2C + 2Na + N_2 = 2CNNa + 50 \text{ cal},$$

we find only one gaseous substance, the other two being solid or liquid; the enormous quantity of 50 cal for one gaseous molecule leaves no doubt of the possibility of the reaction. This, in fact, I had proved before I knew of Castner's experiments.

A current of pure nitrogen passing over a mixture of carbon and sodium has given me cyanide, although the yield in two or three preliminary trials has not been high. Castner had already made similar experiments in 1894. He poured molten sodium slowly over carbon heated in a vertical cylinder, while a current of nitrogen entered the cylinder sideways. The cyanide formed ran off at the bottom. The yield of cyanide was thus greater than by sending the nitrogen into the mixture of carbon and sodium. Castner soon found, however, that it was better to replace the elementary nitrogen by ammonia gas.

In the first period of the manufacture of cyanide, Castner operated successively in two apparatuses. The first one served for the production of sodium amid at 300-400°, the second one converted the amid into cyanide at 700-800°.

2. PREPARATION OF SODIUM AMID

Sodium is acted upon by ammonia in a horizontal rectangular retort A, the bottom of which is slanting, in order to facilitate the movement of the products (see Fig. 1). That part of the retort above the liquid metal M is divided into compartments by means of

*From *Revue Generale des Sciences*, Vol. 24, pp. 882-86 (1913), translated by Alex F. Fuerst.

vertical partitions C which touch the metallic bath; each of these partitions is fixed ultimately to opposite sides of the retort, as shown in Fig. 2, in order to force the ammonia gas to circulate from one compartment to the other and thus to remain as long as possible in contact with the sodium.

To operate the apparatus, the retort is heated to 300-400° C.; well dried ammonia gas is then sent through the retort in order to replace the air contained in it. The apparatus is then filled through funnel D

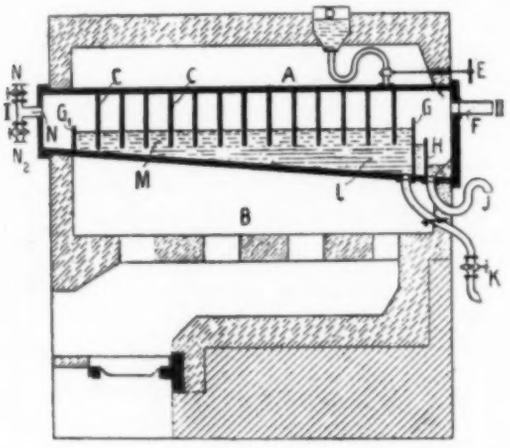

FIG. 1—VERTICAL CUT THROUGH APPARATUS FOR THE MANUFACTURE OF SODIUM AMID

A, Horizontal Retort; B, Furnace Room; C, Vertical Partitions; M, Liquid Metal; D, Funnel for the Introduction of Melted Sodium; N, Entry for Ammonia Gas; Exit for Hydrogen Gas; T, Siphon; E, K, N_1 and N_2, stop cocks.

with melted sodium until it overflows at G and tends to run away through the siphon J; the ammonia gas which is continually introduced through N is gradually absorbed on the surface of the sodium.

The sodium amid which forms is also liquid and as it is heavier than sodium it tends to sink to the bottom of the metallic bath, leaving always pure sodium exposed to the ammonia. The amid passes through a small opening in the partition G into M and can be withdrawn through the siphon J. The ammonia gas is absorbed in theoretical amounts. The hydrogen escapes through F. The amid has become of considerable im-

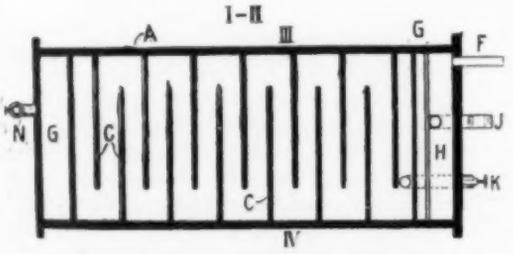

FIG. 2—PLAN OF APPARATUS ALONG I II

portance lately as it is required in the synthetic production of indigo from phenylglycine.

3. MANUFACTURE OF THE CYANIDE

The conversion into cyanide takes place in a cylindrical vertical retort A (Fig. 3) with a conical bottom. The retort is filled with wood charcoal through the funnel C, and heated to 800° C.; melted sodium amid is then gradually introduced; hydrogen escapes through F while molten cyanide runs off through the siphon E into molds where it solidifies.

II. Castner-Roessler Process

Roessler, of the Deutsche Gold und Silberscheide Anstalt of Frankfurt, found that the yield in the second operation could be considerably improved. He found it to be the resultant of two consecutive reactions. At the temperature required for the conversion into cyanide, the sodium amid already undergoes decomposition with liberation of nitrogen and the yield is that much less. Moreover, some sodium cyanamide is found to be present in the cyanide; and the quantity of the cyanamide increases with the lowering of temperature. Thus when sufficient heat is applied some of the amid is decomposed and if the heat applied is not sufficient an increasing amount of cyanamide instead of cyanide is formed.

After much study, Roessler succeeded in obtaining an almost quantitative conversion of ammonia into cyanide by conducting the whole operation in three phases. Formation of amid, transformation into cyanamide, and conversion into cyanide. The second operation takes place at the low temperature of 300-400°, and consequently under conditions in which the amid is stable; further the cyanamide is not decomposed at 800° C., the temperature which is required for conversion into cyanide.

As we have already shown, the conversion of amid into cyanamide may be carried out in two different ways; either by melting the amid together with an equivalent amount of cyanide:

$$NH_2Na + CNNa = CN_2Na_2 + 2H_2,$$

or by heating the amid at 350-400° with charcoal,

$$NH_2Na + C = CN_2Na_2 + 2H_2.$$

This latter is one of the most remarkable reactions since hydrogen is replaced by carbon.

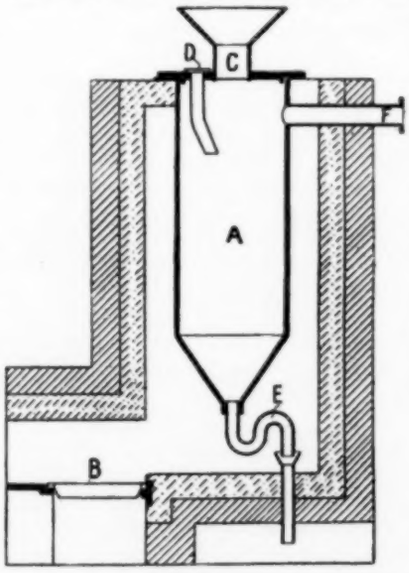

FIG. 3—CASTNER'S APPARATUS FOR CONVERTING SODIUM AMID INTO CYANIDE

A, Retort; B, Furnace Room; C, Funnel for the Introduction of Wood Charcoal; D, Opening for the Introduction of Melted Sodium Amid; E, Syphon for the Removal of the Cyanid.

This operation is carried out as follows: The amid is melted with very finely divided carbon; as soon as a temperature of 380° C. is reached a violent development of hydrogen takes place; at the same time the whole mass loses its fluidity while the reaction proceeds, because the melting point of ordinary cyanamide lies at 550° C. For the completion of the reaction it is, therefore, necessary to raise the temperature gradually to 550 or 600°. Under these conditions the yield of cyanamide is quantitative.

The need of very finely divided carbon is self-evident, since each molecule of amid must find the required amount of carbon for its conversion. The replacement of carbon by liquid or gaseous hydrocarbons has been proposed and the same result is thereby much more easily achieved; acetylene particularly allows of a very rapid reaction, but its use increases the cost.

The process is carried out as follows by the Deutsche Gold und Silberscheide Anstalt and by those companies which are its licensees.

The various phases of the operation are carried out successively in one apparatus, which consists of a number of large iron crucibles. Each crucible is charged with 70 kilograms (about 156 lbs.) of finely divided wood charcoal. Ammonia is passed slowly over the crucible at 500° in order to replace the air; then the current of gas is increased, and 100 kilograms (223 lbs.) of sodium are added. The temperature is slowly raised to 600° C., which is the temperature required for conversion into cyanamide. Under these conditions, neither ammonia nor amid is decomposed. For the conversion into cyanide the temperature is finally raised 800° C. All that is necessary immediately to obtain a commercial product without any further treatment is to let the melted cyanide run into molds. The yield is quantitative, no losses are experienced except those inherent in every manufacturing operation. All that is required is a rigid control of temperatures. The cyanide thus prepared contains 90 to 98 per cent pure cyanide and is equivalent to 120 to 130 per cent of cyanide of potassium, which is the current method of valuation of cyanide.

The Castner process, with these improvements, is used by the Deutsche Gold und Silberscheide Anstalt in their works near Frankfurt; also by the Electrochemische Fabrik Natrium at Rheinfelden; in the United States by the Roessler & Hasslacher Chemical Company; in France by the Société d'Electrochimie. The latter company manufactures sodium in their works at Clavaux (valley of the Romanche, Isere), and manufactures the cyanide at Villers dans l'Oise, the place where Gall and Montlaur carried out their process for the manufacture of potassium chlorate.

Of the 25,000 tons of the annual world production of cyanide, Germany produces one-third, of which she exports about 7000 tons; England is next with a slightly smaller amount, then comes France and the United States, which also manufacture considerable amounts of cyanide.

The Castner-Roessler process, which is the youngest in the cyanide industry, is now of greatest commercial importance; the simplicity of the apparatus and the high yield of the process allow the manufacture of cyanide at a price which defies competition. The question, however, arises, if its future is quite secure.

A new industry is in process of formation, namely that which makes use of the residues which are so cumbersome to distilleries and sugar factories. Numerous and varied products are already being extracted from these residues, for instance, trimethylamin, which is subsequently converted into cyanide. A trial plant which has been erected at Nesles (Oise) produces already 2000 tons of cyanide per year and could produce 3000 tons. When this industry will be extended to its full capacity and when other plants are erected in sugar refining and distilling centers, the production of cyanide should rapidly exceed the consumption. Cyanide will then become a by-product. The cost of manufacture will only depend on the cost of conversion (by simply heating the trimethylamin) and of the necessary soda for the absorption of the hydrocyanic acid formed:

$$(CH_3)_3N = CNH + 2CH_4.$$

Under such conditions it seems possible that the selling price be lowered to such an extent as to defy any and all competition.

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The International Smelting & Refining Co. has awarded to the American Bridge Co. a contract for the construction of its new smelter at Miami.

Electro-Metallurgy of Iron and Steel

BY WOOLSEY MCA. JOHNSON

So much has been written and so much has been said on the details of the above subject that it is of little use to expatiate on it. But the view "en perspectif" of an outsider should give conclusions whose usefulness may be great, according as his vision is clear. Now, the architectonics of the electro-metallurgy of iron and steel is at present somewhat ill-defined, as may be evidenced by the waiting game that iron and steel manufacturers are here and elsewhere playing.

The commercial importance of steel is greater than that of gold, silver, zinc, copper and lead combined, and indeed the trite saying that this age is the iron age is well founded. The commercial importance has a direct bearing on any electrical applications, for so important a metal has been the study of many able minds and the endeavors of many noble wills have been here adduced.

The net practical effect is that the iron blast furnace is the most efficient metallurgical instrument that exists. For instance, its thermal efficiency often exceeds 40 per cent and the saving of labor is likewise satisfactory, for a well-designed blast-furnace plant will have a charge of 30 cents per ton of ore for labor. The open-hearth and Bessemer practice has likewise been brought to a state of "temporary perfection." Economies of different nature have been introduced into the iron and steel industry, as for example, the by-product coke oven in connection with an iron works, gas engines working on blast-furnace gas, the Gailey dry-blast apparatus, and the manufacture of slag cement.

It thus can be reasoned with surety that any electro-metallurgical improvement can only succeed here because of innate fitness. The competition of the existing metallurgical art is active and severe, and more so, I believe, than is the case with any other metal. Possible and potential competition of pyro-metallurgical improvements, e. g., the oxygen-enriched blast, cannot be neglected or depreciated in a review of the subject.

Probably the only serious weakness of the iron furnace is its inability to control rigidly the quality of pig iron and the only serious weakness of the steel business is to make in quantity and at a price commensurate with the demands and needs of civilization steel of quality.

In 1902, at the Niagara Falls meeting of American Electrochemical Society, I commented as follows: "In regard to the making of steel by electro-metallurgical means, I would say that the person who attempts it competes against a 'steam-shovel' proposition. A very large part of the iron ore comes from the shores of Lake Superior, is mined by the steam shovel, is very high grade, and consequently the cost of mining, per pound of iron turned out, is very low. In the case of magnetite, I believe Mr. Ruthenburg intends to treat lean ores. In that case, the cost of mining and crushing is all multiplied by two or three, and sometimes by four or five, according to the percentage of iron in the ores. Therefore, it seems to me that any electro-metallurgical process of making steel can only be successful provided the article which is made is so much better that it compensates for its higher cost. For instance, if the steel is made very hard and free from blowholes, and has no dissolved gases in it, it has a physical texture which might compensate for its higher cost. Ordinary steel, made very cheaply, is good enough for most purposes, and steel made electro-metallurgically must be of the grade of crucible steel. Otherwise the process has no economic value." (Transactions of the American Electrochemical Society, Vol. II, pp. 99-100.)

Like any broad statement this must be construed broadly, but under such construction it still analyzes a rich percentage of truth.

While in the distant and hazy future the iron electric furnace to my mind has certain pregnant chances for general application even in such centers as Chicago or Duluth, especially as the character of future workable ores may modify the iron business, yet for the immediate future even such locations as Norway, Chile and California present but little hope of financial good fortune. The past practical success only exists as a figment of the imagination of the bold pioneer, though the present status is not unpromising in certain places.

It might be thought that with power at $6 per electrical horse-power year, approximately the thermal equivalent of coke at $8 per ton, with cheap ore and with a ready market for the product that the honest efforts of the Norwegian and Swedish pioneers would have met with marked financial success. Likewise, it is a source of wonder to me that with a market for pig iron considerably higher than that of Chicago the commercial experiments on the Pitt River, California, did not win out in short order.

With the work at Norway, the designers had too evidently copied slavishly the general lines of the iron blast furnace—simply substituting electrodes for tuyeres. This is as humorous as the first railway cars, which were merely remodeled stage coaches. If a man wishes to succeed in doing something new, he must depart from tradition while placing a proper valuation on the facts of tradition, and he must do his own thinking.

The designs at Pitt River and the designs of Helfenstein present an advance, but due regard must be paid to the following fundamental truth.

An electric furnace of buried arc or slag resistance type is much more efficient for melting than for reduction and smelting. *This principle is plain and obvious. Most metallurgical reactions require time for completion and to complete any reaction with a maximum of chemical or metallurgical smoothness a progressively intense application of metallurgical means must be used.*

There is a partial exception in case of reduction of zinc oxide by carbon, for both resultant bodies enter gaseous phase at once and in so passing out of sphere of activity give no chemical back pressure and accordingly reaction proceeds efficiently at a high rate. But what success the Continuous Zinc Furnace Company has had at Hartford in condensing 85 per cent of the zinc vapor to spelter while making a fusible slag, copper matte and lead bullion in one furnace and in one operation out of refractory ores, has been due in no small part to a proper recognition of this plain deduction from the laws of physical chemistry and electrothermics. And the moneys wasted in Canada, Norway, France and Germany, partly in large salaries and abortive large-scale experiments, has been due to an ignorance of physical chemistry, thus applied. Parenthetically, it can be stated that one for success must make his mistakes on a small scale.

It can be concluded, therefore, that the way to smelt iron ores electrically is to reduce iron oxides in gradual steps "seriatim" and produce a "sponge-iron" with incipient slagging of mineral impurities. This reduction can be done by combined influence of solid carbon, hydro-carbons, hydrogen and carbon monoxide.

If we have regard for J. E. Johnson, Jr.'s, principle that for each metallurgical condition there is a certain critical temperature at which the reaction velocity is zero and that each degree above that critical temperature the reaction velocity is increased; if we regard the action as going on in 100 or more elemental stages, and if we apply the foregoing to the progressive preheating and "metallizing" of the charge, imparting these heat units from some cheap source, e. g., from the combustion of soft coal, in a thermally insulated apparatus, electrical smelting of iron ores would not be so costly or so inefficient as heretofore. Such a process, if intelligently elaborated, has possibilities.

If by making a counter-current of ferruginous slag we were able to decarbonize and siliconize the iron and produce uniformly a pig iron approaching steel, eliminating progressively also phosphorus and sulphur, we might easily attain a commercial procedure of excellence. Unquestionably the only economic manner of electrically treating iron ores is to deliver an iron sponge to the smelting zone in balanced proportion.

The ultimate commercial method should follow closely the movement of an athlete in putting the shot. He starts the weight by force of muscles of leg, applies muscles of side and body next those of shoulder and arm, then of the wrist, and finally gives last impetus with a neat little "flick" of the fingers. The theory is to put in continuously muscular energy at a maximum efficiency and to increase continuously the velocity of the missile. When well done, it is the apotheosis of bodily grace.

Any metallurgical operation should conform as far as possible to a scheme like that of this analogy. This is well seen in the Hardinge conical tube mill, where the big particles of ore are hit by the large drop of large pebbles, and as size of particle is diminished, the drop and size of pebble hitting it is diminished.

With such a general procedure in mind and with firm control of product that electric smelting gives, there are possibilities of direct application of electrical heat to iron smelting that, though great, do not stretch one's imagination beyond the elastic limit.

Of course, one should never attempt to carry on a refining process where standard quality is desired, in a continuous operation. Where quantity or tonnage is desired, there should the metallurgical engineer employ a continuously acting process. When examining and studying the theory and philosophy of metallurgy some ten years ago, I discovered this fundamental principle: "That for concentration of metallurgical values, a continuous process is a necessity, while for refining an intermittent process is a necessity."

To my mind the fact that proper electro-metallurgy of iron consists in a graduated pre-heating with a final electric smelting of "metallized" product, making a "pig-steel" for subsequent short electric refining, is as clear as crystal. This opinion is based on some practical experience as well as on theory. The future will show how far this is right.

The Electro-Metallurgy of Steel

There are three roads along which future progress will be made in applying electricity to steel metallurgy. Fortunately, we can record some pronounced commercial success in each line, and have generally recognized facts of the past and present on which to base hopes of the future; we have the evidences of things seen for existence of things unseen.

The three present roads are as follows:

(1) Crucible cast steel or alloy steel making.

(2) Steel castings in foundry.

(3) Super-refining of hot steel for "tonnage" steel in a steel plant.

In the first, unquestionably is the largest margin of profit. But an examination of the process for making "tool" steel does not disclose any great lack of satisfaction among user and maker. Much bad steel is sold as tool steel, but a great amount of fine steel is made in crucible to satisfaction of maker, vender and user.

Suppose a shop is using $100 worth of tool steel a year and doing a business of $20,000 a year. Does the manager want to hear about any new-fangled electric steel? He may have heard of some one using it with failure or he may have used it himself with ensuing

trouble, and he has his daily problems. So he does not want to try new things. This is an extreme case, but it is an actual case. Now there are hundreds just like this and larger.

If we suppose that to introduce a new brand of electric steel, half a dozen and one fat-faced, strong-talking, stronger-eating salesmen were at hand, each drawing $5,000 or so per year and having a liberal expense account, could they do it in a year? "If seven maids with seven mops should sweep for seven year, do you suppose, the carpenter said, that they could sweep it clear?"

With such a premium on the importance of selling crucible steel, it is small wonder that the electric steel furnace which would present a new problem and offer in some cases only a few advantages, has made little headway.

Unquestionably, there are innate points of superiority in the electric steel furnace over the crucible. These can be enumerated as follows:

(1) Decreased labor charge.
(2) Dispensing with crucibles.
(3) Increased thermal efficiency.
(4) Control of temperature and chemical conditions.

All these can be summed up in fact that size of unit could be increased at will. Under (4) we might point out that the reaction between oxygen and carbon dissolved in steel comes slowly to equilibrium and that so-called "dead-killing" done in crucible can be effected much more easily in the electric furnace, and that a dense ingot can be better obtained by electric furnace than by crucible.

If we consider the electric steel furnace for alloy steel we see that its control over reductivity profoundly affects the commercial conditions in dealing with easily oxidized elements, as manganese, chromium, etc.

If I were going into the electric tool steel business, I would choose some special new field like the production of steel for mine drills. Here the advent of small high-speed hammer drill has brought a necessity for a better grade of steel, selling, say, for 8 cents per pound. This would give the newcomer more of an even chance, especially as the purchasers would buy in large blocks and would be guided by technical advice.

In arguing pessimistically in all the above, I disclaim any intention of doing anything but pointing out the general great commercial inertia and friction that confronts this and every similar innovation. My conviction of the gradual commercial success of the electric tool steel furnace is no less strong even if I see clearly the forces opposing it.

Electric Steel Castings

In the steel castings we have much greater chances for an immediate broad expansion of the electric steel furnace. The economic freedom is great. For instance, in every industrial center there is a growing demand for steel castings from many consumers, and there is produced often by some people a large amount in the aggregate of steel drillings and turnings, "fins" from drop-forge bar plant, all of good chemical quality and all sold at a discount because of physical nature. Some of this contains oil enough to do all the pre-heating under which procedure the energy consumption would be reduced to 350 kilowatt hours per ton of product. Besides this there is often "off-peak" power that could be purchased from central stations for 7 mills to 9 mills.

Under such conditions it is perfectly possible to produce liquid steel suitable for castings for $26 per short ton; in fact this is an accomplished commercial fact. With a good-sized plant and especially favorable conditions it is quite probable that liquid steel could be made for $18 per short ton, and this is not the ultimate. The "baby" converter which uses a "high-silicon" low-phosphorus pig iron costing at an average of over $20 per ton has a serious rival in the electric furnace for production of smaller castings.

The quality of electric steel is high and its physical properties are such that with careful molding a higher percentage of merchantable finished castings can be expected. It must be realized that in any foundry careful planning of the molding work is a *sine qua non*, and the electric steel foundry should have ability equal to that of competing plant. Molding is at least 50 per cent. of the battle of the electric steel foundry.

We may even hazard the prediction that the open-hearth steel foundry has a potential competition in the electric furnace on large castings.

Tonnage Electric Steel

In considering this subject we see that the legitimate hopes of the pioneers have been deferred. In apposition to this is the opposition to the electric furnace by the old-time steel men. This is a perfectly natural human feeling.

The adventurous-minded are a benefit to the community, but if all their apparently good schemes were put into effect, capital would be destroyed faster than it could be created. With the stupendous investments in rail, sheet, plate, wire, tube and shape mills it would be folly to suppose that those controlling such plants would care for a sudden change. For instance, if all structural material were made of electric steel, all the handbooks for bridge work must be revised, for in this work often 80 per cent. of the steel is put in to hold up its own weight, and if one can lighten one piece that enables one to decrease weight of a second, and so on.

Things that are in order must not be put in disorder, for progress should be orderly. In spite of all that the detractors of society say and because of what the busy workers in society do, things operate largely to the final benefit of the state and of each individual.

In the manufacture of tonnage steel it is natural to give this a first quick refining in the Bessemer or open-hearth furnace, pour the partially refined steel into the electric furnace, finish the refining there by use of a slag high in lime, allow reactions to come to equilibrium, the gases to pass off and the impurities to come to the top, and after this "dead-killing" is accomplished, to pour the metal into ladle. It was this accomplishment with the discovery of the "calcium-carbide" slag and the practicalization of the "series arc" furnace that was the second great contribution of Paul L. T. Héroult to electro-metallurgy.

This electric process has given new life to the Bessemer converter, and there are those that see a "triplex" process, Bessemerizing basic open-hearth treatment with final electric furnacing, as the process of the future. This may well be for certain large installations.

Certain it is that when operating in a large way on "duplex" process, the electric furnace can make steel of a superior quality at a cost slightly, if any, above the cost of that made by fire in a single operation. With the demand as pressing as it is now for "high-duty" steel rails, it is likely that the first marked commercial expansion in tonnage electric steel will be in the way of making a quality steel rail.

Other Possible Application of Electrothermics in Metallurgy of Iron and Steel

These uses of the electric furnace are humble but none the less important, for they give an untrammeled chance for individual initiative. With control of heat possible by electric means and efficiency of electric furnace of "soaking-heat" type, it is not difficult to design

an electric furnace for case-hardening, tempering or heat treatment that will work fairly well. To make one that is fool-proof and so have a ready sale is a commercial feat worthy of respect. But it will be accomplished.

The heating of forge bars has been tried. While, if made practical, it would be attractive, commercially considered, yet the practicalization of the forge-bar furnace is not yet done. In the analysis of its advantages we see the fact that no "scale" would be formed. This would save money, especially when expensive high-speed tool steel were used, in decreased loss and in saving on wear and tear of dies when hard oxide was removed from metal.

Electric welding has been in successful operation for years and is bound to expand.

Two more possible avenues of electrothermic advance remain. One of these is super-refining and superheating of cast iron for special castings. This has been tried and is proven to be promising and is in a measure successful.

The other avenue is the malleablizing of castings. It is not impossible to design a practical continuously acting pre-heated malleablizing electric furnace, and one so conceived and so developed intelligently, would have a definite sphere of usefulness for large-scale work.

In attacking and analyzing the problems in the electro-metallurgy of iron and steel one is amazed by the amount of work that awaits the investigator. This work is not in itself easy and the competition of older methods is hard. The rule should be to operate as Nature does, along the line of least resistance.

Fiftieth Anniversary of the School of Mines of Columbia University

The celebration of the fiftieth anniversary of the School of Mines of Columbia University will begin on May 28 with a reception in the gymnasium, at which the alumni will be welcomed by the President of the University, the Dean of the School of Mines, the Senior Professor, Henry S. Munroe, the Chairman of the Celebration Committee and their wives, while the other members of the faculty and the committee and their wives will assist.

In the forenoon of May 29 there will be a big meeting in the gymnasium, at which President Nicholas Murray Butler will preside, and degrees will be given to prominent Alumni of the School of Mines. It is also expected that there will be sectional meetings of the various engineering graduates in the afternoon, with the first lecture in the Charles F. Chandler Foundation by an eminent chemist, at which Dr. Chandler, the last survivor of the founders of the School of Mines, will preside.

With the beginning of the next scholastic year, in September, will come the consummation of a plan conceived by the founders of the school, half a century ago—a graduate school of engineering—on the same footing as the other graduate schools of the University. Under the new plan three years of specialized study in the various branches of engineering will be offered, leading to the several technical degrees in the Schools of Mines, Engineering, and Chemistry. The requirements for admission to these schools will be the completion of at least three years of a college or scientific school course, including thorough instruction in mathematics, chemistry, and physics; and in addition certain courses in drafting, shopwork, surveying and mineralogy.

Analysis of Natural Gas

BY W. D. BROWN

The analysis of natural gas has always been troublesome. In the methods in general use, the methane and ethane are exploded or burnt slowly with excess oxygen and the resultant decrease in volume and the carbon dioxide formed noted; from these the percentages are calculated. If but little, say, 10 c.c., of the methane and ethane are exploded with oxygen, any error in reading is multiplied many times. Again on combustion of a large quantity with oxygen, the resultant gas is nearly pure carbon dioxide and, its solubility in water varying with its percentage, a relatively large quantity is dissolved. The second contraction, i.e., on absorption of carbon dioxide being low, the result is that the sum of the methane and ethane obtained by calculation is over 100 and the nitrogen a minus quantity. To overcome these defects a method was devised in which the contraction on explosion and on absorption of the carbon dioxide is treated as one known factor, the oxygen entering into combination being the other factor. The explosion pipette, however, contains mercury covered with ¼ in. to ½ in. of water.

Purity of Oxygen

The method as here given refers to the standard improved Orsat of the United States Steel Corporation,[1] but applies to any other apparatus equally as well. The determination of the percentage of oxygen in the commercial oxygen is made by exploding a large quantity of it with hydrogen and noting the resultant contraction, of which one-third equals the oxygen. This is best accomplished in the following manner: about 100 c.c. of pure hydrogen are forced into the burette, the capillary is filled with water from the explosion pipette, a reading is taken, and the gas forced into the explosion pipette until the water level is at 100; about 50 c.c. more hydrogen is then introduced and a reading is taken and the gas forced into the explosion pipette until the water level is at 100. About 60-65 c.c. oxygen are then added, a reading is taken and 15 c.c. portions are sucecssively introduced into the explosion pipette and exploded; after the final explosion, the residue is drawn over, the capillary being filled with water, and a reading is taken. One-third of the contraction is the oxygen, from which the percentage can be calculated.

The Method

Exactly 100 c.c. of the gas are measured in the burette and carbon dioxide determined as usual by absorption in potassium hydrate. The solubility of the higher paraffins in fuming sulphuric acid inhibits its employment for the determination of ethylene in natural gas. Burrell (Bulletin No. 19, Bureau of Mines) uses a 1 per cent solution of palladium chloride as a qualitative test for ethylene. By placing the above solution in an Orsat absorption pipette it has been possible to make the test quantitative. Accordingly, the gas is passed three times through the palladium chloride solution, returned to the burette and measured; the diminution in volume represents the percentage of ethylene and any carbon monoxide or hydrogen in the gas. These gases are generally absent; however, their absence should be proven or the amount determined as shown later. One-half the residue is then discarded and the remaining half passed into the phosphorus pipette for the absorption of any oxygen in the gas originally or through error in sampling. While the oxygen is being absorbed in the phosphorus pipette

[1] This Journal, IX, 302.

about 130 c.c. of nearly pure oxygen are measured and transferred to the explosion pipette. This is done in the following manner: nearly 100 c.c. of oxygen are forced into the burette, the capillary is filled with water from the explosion pipette, a reading is taken, and the gas forced into the explosion pipette until the water level is at 100, the capillary being full of oxygen; about 30 c.c. more of oxygen are now forced into the burette, a reading is taken, and the gas is forced into the explosion pipette, the capillary being filled with water from the burette. The gas in the phosphorus pipette is then drawn into the burette and measured, the oxygen being thus determined. About 10 c.c. of the gas are then forced into the explosion pipette and exploded. This is repeated until all the gas has been exploded, care being taken that the last portion is well mixed before the explosion. The resultant gas is then forced to bubble through the potassium hydroxide solution and finally is transferred to the burette, the capillary filled with water, and a reading taken. The sum of the impure oxygen added and the residue exploded minus the residue after absorption of carbon dioxide is contraction "A"; or, the difference between the last two readings plus the impure oxygen added equals "A." Hydrogen is then added to the capacity of the burette and the mixture exploded and the contraction "C" noted.

From the above contractions ("A" and "C") and from a knowledge of the amount of oxygen in the commercial oxygen, the methane, ethane, and nitrogen may be calculated, the absence of hydrogen and carbon monoxide being assumed for the time.

The reactions of burning methane and ethane are as follows:

$$CH_4 + 2\,O_2 = CO_2 + 2\,H_2O$$
$$2\,C_2H_6 + 7\,O_2 = 4\,CO_2 + 6\,H_2O.$$

From these it is seen that the total contraction on combustion and absorption of methane and ethane are 3 and 9/2 times the volume of the respective gases; or that "A" $= 3\,CH_4 + 9/2\,C_2H_6$. Likewise the oxygen consumed (Oc) is 2 and 7/2 times the volumes of the respective gases; or $Oc = 2\,CH_4 + 7/2\,C_2H_6$. Also it is clear that the oxygen consumed equals the oxygen added (Oa) minus the oxygen entering the second explosion, which is 1/3 C or $Oc = Oa - 1/3\,C$.

From these equations the following are derived:

$CH_4 = 7/3\,A + C - 3\,Oa$

$C_2H_6 = (A + 1/3\,C - Oa) - CH_4$

N_2 = residue exploded $- (A + 1/3\,C - Oa)$.

Example—Data.

Burette Readings

	PURITY OF OXYGEN		
Hydrogen added	1.0	99.0	
Hydrogen added	48.2	51.8	
		150.8	
Impure oxygen added	38.2	61.8	
		212.6	
Explosion	68.0	32.0	
		180.6	Contraction
		60.2	

60.2 + 61.8 = 97.4% oxygen in commercial oxygen.

	GAS ANALYSIS	
Gas measured	0.0	
Potassium hydroxide	0.2	0.2 carbon dioxide.
Palladium chloride	0.6	0.4 ethylene.
	99.4	
	49.7	
	50.3	
Stick phosphorus	50.3	0.0 oxygen.
Impure oxygen	0.6	99.4 oxygen.
Impure oxygen	66.3	33.7 133.1 = 129.64 c.c. pure O_2 added.
Explosion and absorption	77.4 — 50.3 = 27.1	
	160.2 = contraction "A."	
Hydrogen added	9.7	
Explosion	63.7	54.0 = contraction "C."

CALCULATIONS

7/3 of 160.2 + 54.0 — (3 × 129.64) = 38.9 = methane.

(160.2 + 1/3 of 54.0 — 129.64) — 38.9 = 9.66 = ethane.

49.7 — (160.2 + 1/3 of 54.0 — 129.64) = 1.14 = nitrogen.

Carbon dioxide (CO_2)	0.2
Illuminants (C_2H_4)	0.4
Oxygen (O_2)	0.0
Carbon monoxide (CO)	0.0
Methane (CH_4)	77.8
Hydrogen (H_2)	0.0
Nitrogen (N_2)	2.3
Ethane (C_2H_6)	19.3

Calorific Value

An average of the values for ethane given by Berthelot, Guldner, Thomsen, and Payne is 1760 B.t.u. per cubic foot dry gas at 62 deg. Fahr. and 30 in. mercury for the gross. The net is found by subtracting from the gross, 150 B.t.u., a value obtained from the tables of Marks and Davis. The net is then 1610 B.t.u. The net B.t.u. of methane and ethylene is 912 and 1491 respectively. The calorific value of the gas cited is then 1026 B.t.u. net. In general the gross is found by adding $1/2\,(H_2 + 2\,CH_4 + 2\,C_2H_4 + 3\,C_2H_6)$ to the net.

Determination of Hydrogen and Carbon Monoxide

The absence of these gases was assumed in the preceding method. It is advisable to prove their absence or to determine their percentage. For this purpose, the supply of hydrogen is disconnected and a palladium tube connected to the end of the apparatus, the other end of the palladium tube is connected to an absorption pipette containing water. The palladium tube is immersed in a beaker of water at 90-100 deg. C. and oxygen passed through the tube to oxidize any hydrogen present. The water is drawn to a specified point on the absorption pipette and the capillary tube of the apparatus filled with water from the explosion pipette. Fifty c.c. of natural gas are then introduced into the burette and measured, and the carbon dioxide, ethylene, and oxygen removed as usual. About 10 c.c. of oxygen are then added and a reading taken. The gases are then passed back and forth through the palladium tube. which is immersed in hot water at first and then in cold water to cool the gas. The gas is finally brought back into the burette, the water in the pipette being at the previous level, and a reading taken. The diminution in volume is noted as contraction a. The gases are then passed into potassium hydroxide, drawn back and measured; the dimunition in volume is contraction b.

From a study of the contractions formed in the combustion of carbon monoxide and hydrogen it is seen that

$$CO = b$$
$$H_2 = \frac{2\,a - b}{3}$$

If a contraction has been found here, denoting the presence of hydrogen and carbon monoxide, or either, these contractions would have occurred in the determination of methane and ethane by explosion. In this case the sum of "a" and "b" must be deducted from contraction "A" and added to contraction "C."

Duquesne Works, Carnegie Steel Co.

Coarse Crushing Plant of Utah Copper Co.—The redesigned coarse crushing plant at the Magna plant of the Utah Copper Company, where 16,000 tons of ore are daily handled, is the subject of a profusely illustrated article in No. 63 of the Labor Saver, published by the Stephens-Adamson Mfg. Co., of Aurora, Ill. The entire volume of ore was formerly handled by an extensive system of cars, carrying from the bins to the crushers and thence to the reduction mill. The most important feature of the new design is the extensive use of Stephens-Adamson apron feeders and belt conveyors. The redesign is stated to have resulted in great savings.

Radium Hearing at Washington

[Editorial Correspondence]

In our last issue we gave a statement of the federal-state controversy over the proposed conservation of radium-bearing ores in the United States, and showed particularly the attitude of the Secretary of the Interior and his desire to prospect for, mine and treat such ores under federal direction. Since that writing, and in deference to the protest raised by Colorado miners and prospectors, state authorities and companies interested in producing radium, the House committee on mines held a hearing in Washington, at which it sought to get full and complete information on the status of radium industry in this country. All interested parties were heard, and the record has been published.

Much of the record must be classified as light reading; it will be appreciated only by those who have a knowledge of the facts plus a saving sense of humor. There were, however, some matters introduced that will be of interest because they officially enlighten the public on points that formerly were matters of conjecture, rumor or personal opinion.

The gist of the testimony of the opponents of the federal plan of development was a fundamental objection to interference by the United States in the exploitation of the radium-bearing ores and a belief that such deposits would be best and most quickly developed by private enterprise. A point not brought out, but which is worthy of consideration, is that if the government engages in the metallurgy of radium and publishes its methods of operation, patentees of similar processes, who have devoted their time and money to the discovery of suitable methods of treatment, may be deprived of the benefits of their work. Having sought and secured the protection which a patent is assumed to offer, they may find it difficult, if not impossible, to gain the rewards to which they are entitled by their ability and energy. This complaint against government operation in the radium industry is probably worth more than most of the objections brought out at the hearing.

The Government and the National Radium Institute

It developed early in the hearing that there was a misunderstanding regarding the relations existing between the government and the National Radium Institute. The latter is financed by Dr. James Douglas and Dr. Howard A. Kelly, who have completed a plant at Denver for the treatment of carnotite. At the hearing the motives of these gentlemen were impugned and their action was characterized as mercenary. This resulted in making public the following letter from Dr. Kelly to the Bureau of Mines, stating the terms on which a cooperative arrangement was sought and secured.

New York, October 7, 1913.

The Director, Bureau of Mines.

Sir: The National Radium Institute (Inc.) is a corporation duly organized and existing under and by virtue of the laws of the state of Delaware and is interested in the study of the best methods of producing uranium, vanadium and radium, and in the mining and concentration of ores from which these products may be obtained for use in radium therapy. It is interested in certain carnotite and other suitable ores mined in Colorado from which those products are obtainable.

For the benefit of the people and to secure the advantage of a scientific and technologic study of efficient methods of production, as well as mining and concentration of the ores, without waste, the institute solicits the co-operation of your bureau—that is, the services, under your supervision, of enough chemists and mineral technologists connected with your bureau as may be necessary for the proper technical control and supervision of the mining and concentration of carnotite and other suitable Colorado ores, in the study of the methods outlined and generally in the prosecution of the investigation contemplated, the results to be published by you.

To aid in such work, the institute will furnish the sum of $150,000, to be available as follows, and to be expended after consultation with us as you advise: $70,000 during the year ending August 30, 1914; $40,000 during the year ending August 30, 1915, and $40,000 during the year ending August 30, 1916, it being estimated that about three years are required for the exhaustive investigation that is desired. The funds received from the sale of any by-products other than radium belong to us, and may also be used in the prosection of this work. It is proposed to expend this money in the mining of the carnotite or other suitable ores, to an amount of 1000 tons, more or less, of high-grade ore (over 2 per cent), or in the purchase of such ores as are necessary to an adequate study of the subject, and in the establishment and operation of a plant for the working up of said ores; also in the erection and operation of a small concentration plant for the treatment of any low-grade ore (less than 2 per cent U_3O_8) as may be mined or purchased, and, of course, in the payment of necessary wages of the plant operatives.

The institute also is entirely willing that any radium produced in excess of 7 grams of anhydrous radium bromide ($RaBr_2$) from any 1000 tons of carnotite ore may be donated to the bureau for further experiment or study.

As the institute has already on hand 100 tons (more or less) of carnotite, it is made a condition of this offer that this ore be first extracted far enough to demonstrate to the satisfaction of the institute the practicability of the processes employed.

Until this is done no more than $5,000 shall be expended on mining or concentration.

At the completion of this demonstration, the undersigned may withdraw from this project, and shall not thereafter be liable for any further expenditures of money other than sufficient to take up all obligations incurred up to the time of the said withdrawal, and no further demands on account of said $150,000 shall be made. All expense incurred in said transactions shall in any event be on account of said $150,000.

The institute would esteem it a favor if its co-operation should be recognized on the cover and title page of any published report of the results of this investigation.

If this proposition is acceptable, will you not kindly advise the institute as soon as you conveniently can?

Respectfully,
National Radium Institute (Inc.),
By HOWARD A. KELLY, *President.*

Attest:
ARCHIBALD DOUGLAS, *Secretary.*

In addition to this letter, the Secretary of the Interior also introduced telegrams from Drs. Douglas and Kelly, stating that they were willing to make gratuitous transfer of the Institute's plant to the government on the termination of the three-year agreement.

The Secretary also reiterated the governmnt's intention to develop the radium industry at the earliest possible moment, and not retard it in any way nor lock up the resources of the states. His plan involved the withdrawal of some 10,000 square miles of land in Colorado and Utah, dividing this into 320-acre tracts and giving a prospector the exclusive right to search for radium-baring ores on such a tract, and to protect him in any discoveries. If ore was developed and mined the government might either receive a part or all of it for treatment, allowing the balance, if any, to reach the commercial market. No present holdings would be affected, while new prospecting would be stimulated and a domestic market assured.

The House Radium Bill

As a result of the hearing a compromise bill has been introduced in the House. The original idea involved withdrawal and a leasing system, but this has been abandoned in an effort to harmonize the various interests. At the time of writing another hearing is in progress before a Senate committee, but it is expected that the results will not materially affect the present status, and that a bill similar to the following will be passed.

A BILL

To provide for and encourage the prospecting, mining and treatment of radium-bearing ores in lands belonging to the United States for the purpose of securing an adequate supply of radium for Government and other hospitals in the United States, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress Assembled, That all deposits of carnotite, pitchblende, or other ores, containing radium in sufficient quantity for extraction, in lands belonging to the United States, and the lands containing the same, shall be subject to exploration, occupation and purchase under the mining laws upon condition that said radium-bearing ores shall be exclusively sold and delivered to the United States as hereinafter provided, and all said ores hereafter mined from lands the title to which is now in the United States, and which were not located under the mining laws of the United States, and of the States wherein the same are situated prior to the fifteenth of January, 1914, shall be so sold and delivered, and the exclusive right of the United States to purchase and receive said ores from the owners of such lands, their lessees and assigns, together with the right of the United States to annul and void any patent issued for such lands because of failure to develop and mine such ores with reasonable diligence, shall be expressly reserved in any and all patents which may hereafter be issued.

Sec. 2. That the locators of lands containing said deposits of radium-bearing ores shall prospect, mine and develop such deposits continuously and in good faith, and failure to prosecute

such prospecting, mining and development on lands chiefly valuable for said deposits for a consecutive period of four months in any calendar year shall subject the same to relocation, or in the absence of relocation, to the forfeiture at the discretion of the Secretary of the Interior: *Provided*, That the Secretary of the Interior shall have authority by public notice to suspend for such period as he may fix the requirement of continuous development as hereinbefore provided.

Sec. 3. That the sale, gift or other disposition of said radium-bearing ores to any person, association or corporation other than the United States shall be unlawful, and any violation hereof shall subject any location made or patent issued to forfeiture, and the person, association or corporation so selling, giving or otherwise unlawfully disposing of said ores shall, upon conviction thereof, be punished by a fine of not less than twice the value of the ores so sold, given away or unlawfully disposed of: *Provided*, That when in the opinion of the Secretary of the Interior special conditions arise which make such action necessary he may, by special order, permit the sale and delivery of said ores after or without tender to the United States, as he may deem advisable.

Sec. 4. That the Secretary of the Interior be, and he is hereby, authorized to erect, maintain and operate a plant or plants for the concentration and treatment of radium-bearing ores and the extraction of the radium and by-products therefrom; to purchase radium-bearing ores mined from lands occupied and held under the provisions of this Act at such prices, to be fixed by him from time to time and published in advance on the first day of January and July in each year, as will insure the prospecting for and mining of such ores, and, if need arises, to purchase or accept radium-bearing ores from other sources; to sell the by-products of such ores at the best prices obtainable; and he shall make such disposition or use of the radium produced as will best serve the need of the people of the United States.

Sec. 5. That the Secretary of the Interior shall report to Congress at the beginning of each regular session all receipts, expenditures and operations under the provisions of this Act, with such recommendations concerning future operations as he shall deem proper. All mining operations on lands located as herein provided for shall at all times be subject to inspection by authorized representatives of the Secretary of the Interior, and the locators or patentees of such lands, their lessees and assigns, shall transmit monthly to the Secretary of the Interior or to his authorized representative a statement of all developments, the nature thereof and the quantity of ore mined.

Sec. 6. That there is hereby authorized for the erection and general equipment of a suitable building or buildings for the radium extraction and other work of the Bureau of Mines in the metal mining States the sum of $150,000, and for the necessary expenses connected with the purchase and treatment of radium-bearing ores and the extraction of radium therefrom during the fiscal year ending June 30, 1915, the further sum of $300,000.

Sight-Flow Indicator.—Bulletin 57, "The Phenix Sight Flow Indicator," recently issued by The Richardson-Phenix Co., of Milwaukee, Wis., illustrates and describes how this little device can be inserted in any pipe line carrying a liquid, such as water lines of water-cooled transformers and the supply pipes of water jackets of gas engines and air compressors, and how it shows at a glance or indicates electrically by lighting a lamp or ringing a bell when the flow of liquid is interrupted. Several recent improvements in the Sight-Flow Indicator are also described, making it now possible to adjust the indicator so that it will give an alarm before the liquid stops flowing entirely, that is, when the speed drops to some predetermined minimum. This improvement has made it especially suitable for use on water-cooled transformers.

Pickling Machines.—Bulletin M of the Mesta Machine Company, of Pittsburgh, Pa., entitled "Mesta Improved Pickling Machines," describes these machines which have several interesting, novel features. The first is that mechanical action is brought into play to such an extent that the material is pickled with about one-half of the acid and labor required in hand-pickling. For this purpose the material to be cleaned is moved through the acid with a predetermined velocity and a slight jar at the end of each down stroke. If sheets are pickled, the jarring action at the end of the stroke separates and shifts the sheets sufficiently to allow the acid to enter between them and to prevent their sticking together. The acid washing over the surfaces has, in conjunction with the loosened particles, a scouring action which thoroughly cleans the sheets. The uniform action of the acid upon the surfaces is assisted by the thoroughness of the agitation, which does not allow acid layers of different density to form.

The Buffalo Forge Company has opened offices at 176 Federal Street, Boston, Mass., for its fan, ventilating and pump departments, being represented in the New England territory by Mr. B. R. Andrews, formerly with the B. F. Sturtevant Company.

The Boiler Plant of the Blast Furnace

BY J. E. JOHNSON, JR.

In the early days of blast furnaces when tonnages were small and the quantity of iron made per cubic foot of furnace capacity was also very small as compared with present practice, the quantity of power required to drive the furnace was relatively insignificant. But even in that early day it was so considerable that plants were generally located with reference to a water power site, the gases from the top of the furnace being allowed to burn to waste in the air.

With increase in size and rate of driving, the amount of power required increased very rapidly. We shall see in a later article that this increases nearly as the square of the output of a given furnace, and that modern furnaces require from 2000 to 3000 horsepower to drive them. Consequently as furnaces were driven harder it became more and more difficult to find water power adequate to drive them. This, with the increasing introduction of the steam engine in suitable sizes and designs, and the increasing realization of the vast fuel value of the furnace gases, led to the introduction of steam power for blowing furnaces.

This step was hastened by the advent of anthracite as a furnace fuel, the pressures required with it being so much greater than they are with charcoal fuel in a given size furnace, and under similar conditions in other respects.

The question of the quantity of furnace gas per ton of iron produced and its heating value will be treated at some length in a later article, but in tracing the development of the present subject we may say that in ordinary, good modern practice about one-half of the total thermal value of the fuel charged comes out of the top of the furnace in the form of its top gases. Some 10 or 15 per cent of this heat is in the sensible condition, the rest is contained in the gas in the shape of CO, whose combustion with air gives 4370 B.t.u. per pound of CO, or 10,200 B.t.u. per pound of carbon contained.

In good modern practice there are in the average produced about 140,000 to 200,000 cu. ft. of gas, of which about 60 per cent by volume is nitrogen, and the remaining 40 per cent is made up of CO, CO_2 and hydrogen in varying quantities; this gas contains from 90 to 115 B.t.u. per cubic foot.

In Lake ore practice the quantity used is from 140,000 to 160,000 cu. ft. per ton of iron; the analysis approximates N 60%, CO_2 15%, CO 23%, H_2 2%, and the heating value 95 B.t.u. per cubic foot.

In districts where leaner ores are used and correspondingly more coke is required the percentage of nitrogen does not alter much but the CO increases at the expense of the CO_2 with proportional enrichment of the gas and increase in its thermal value.

In the early furnaces, and in a few cold blast charcoal furnaces to this day, this gas was allowed to escape freely from the top of the furnace, from which it burned continuously in a great flame, visible for miles at night.

The first attempts to utilize this heat for heating the blast and for raising steam were made by setting hot-blast stoves and boilers at or near the level of the furnace top, building a masonry flue completely around the top of the furnace with ports leading from the furnace top into this flue, and a powerful chimney at the far end of the combination. This chimney drew the gas, mixed with air, through the ports into the flue and thence into the boilers and hot-blast stoves. The mixture of gas and air was,

of course, made at the furnace top, and so only flame was drawn through the flues.

At a later day the top of the furnace was closed by a huge inward opening valve, universally called the "bell," consisting of a cone, generally with a slope of about 45 deg., turned true in its lower portion and fitting against a similarly turned seat on the bottom of the "hopper," which in turn made a tight joint with the furnace lining, or in later times, with the shell.

All this will be described at length in dealing with the furnace top; suffice it for our present purpose to say that the charge in several portions is dumped into the hopper and rests in the bell which normally is kept closed when the charge is completed, the bell is opened long enough to allow the charge to slide into the furnace, and immediately closed. The total period during which it is open is seldom or never 5 per cent of the total time, and it is only during this period that the gas has an opportunity to escape, the remaining 95 per cent of the gas being confined and forced through the ports at the top of the furnace into the brick-lined pipes which take it to the points of consumption. In this case the furnace is kept practically air-tight, and the pressure of the gas is always somewhat greater than that of the atmosphere, to overcome resistance offered to its passage by the gas pipes, consequently when the bell is opened air does not flow in but gas flows out. As a result air never, in proper operation, enters the top of the furnace, and as the gas contains no oxygen it is perfectly non-combustible in the absence of air.

In this system, therefore, the mains carry not flame but gas, which may even be reduced to atmospheric temperature and still remain an excellent combustible.

Under these conditions the gas can be led without difficulty to very considerable distances and consequently the stoves and boilers can be located with reference to other considerations. They have accordingly, for many years past, been placed on the ground and in positions best suiting the convenience of the plant as a whole.

This gas containing, as has been said, roughly 50 per cent of the total energy of the fuel charged, supplies the heat necessary for all the operations around the plant outside the furnace itself. Its first and foremost use is for the purpose of heating the air, with which we have no present concern. This, in good practice, consumes about 40 per cent of the total gas. In first-class modern practice another 10 per cent is required for blowing power, and 5 per cent for miscellaneous purposes around the furnace, hoisting, pumping water etc., leaving 45 per cent of the gas, or nearly 25 per cent of the total energy of the fuel charged available for purposes entirely separate from the furnace.

The steam plant at the blast furnace has been until very recent years a poor and inefficient one, measured by the standards prevailing at similar periods in other lines of industry. The reason for this is not far to seek. When the closed-top furnace was introduced, and it was found that the gas could be forced by this means to any desired point within reason, it soon developed that the furnace possessed a source of power ample for its needs, even with the cheapest and simplest type of steam plant.

Steel mills at that early day were not generally built immediately in conjunction with furnace plants as they are today, and the latter, therefore, did not have in general any local market for the surplus power, and until the general introduction of electricity for lighting and power transmission there was no disposition for power except such as could be developed immediately where it was to be consumed. Hence there was no use for surplus power which might be developed by the use of economical machinery, and as this machinery was higher in first cost, and more expensive to operate than the simplest and plainest type, the latter was in almost universal use until within the last fifteen or twenty years. Slide-valve or piston-valve engines with late cut-off and little expansion, using low boiler pressure and, non-condensing, were the rule.

The boilers likewise were of the cheapest, simplest and generally most inefficient types. Plain cylinder boilers with their enormous settings and proportionately enormous air leakage were the prevailing style until within the last twenty or thirty years. These boilers were literally plain cylinders, sometimes a pair set side by side, from 3 to 4 feet in diameter and 40 to 50 feet long, entirely without flues. Sometimes there were two pairs, one above the other, the lower one joined to the one vertically above it by necks on each outside or "high" sheet, the whole suspended from two or three suspension points and exposed to the flame up to a height just below the water level in the upper cylinder, the gases making only one pass straight through to the chimney connection.

On account of their enormous water contents in comparison with their heating surface, these boilers possessed a great quantity of preserved energy, and steam pressure would not drop injuriously during a few minutes suspension of the gas supply. They were also very easy to clean because containing no tubes. Men could be put inside them and chip off the scale with chisels or with axes which, of course, is impossible in other types of boilers except as to a small fraction of their heating surface.

Other than this these old types of boilers had little to recommend them, as the great cost of the setting and the high price per square foot of their heating surface made their cost per horsepower installed about as high as that of better types.

The great increase in the tonnage of iron produced in a furnace of a given size, which might almost be said to have culminated with the Duquesne revolution, and the increase in the size of the furnaces themselves, both acted in the same direction, that of requiring a higher blast-pressure to force the desired quantity of blast into the furnace. This in turn required more power, and, therefore the practice which had been adequate if not ample for the old conditions became inadequate for the new because its consumption of steam was so great that the combustion of the furnace gas available was frequently unable to supply the quantity required. When this occurred it was necessary to burn coal under the boilers, and such coal represented a dead loss to the operation.

During the same period the integration of iron and steel plants developed extensively. Furnaces were built at large steel plants, or steel plants at furnaces in order that direct metal from the furnace might be used at the steel plant with a great saving in expense for both, the furnace sending the iron in ladles to the steel plant and so avoiding the cost of casting and handling it, while the steel plant avoided the greater cost of remelting it.

The well-equipped furnace plant having generally if not always, a considerable excess of steam at its command, advantage was taken of this fact by running a steam pipe from the furnace boilers to the steam mains at the steel mill, the latter using enormous quantities of power, but having no source of supply of its own except by burning coal or other commercial fuel.

The great value of the power so supplied became more and more appreciated and the power plant at

the blast furnace was gradually improved so as to leave a larger margin of gas available for the steel mill, and this process has now gone on until some of the finest and most economical power plants in the world are those employed in blowing blast furnaces, while the subject of power development for this purpose has enlisted closest attention in Europe as well as more recently in this country.

It is a rather interesting fact that this gradual progress from the utter indifference which came from having a prodigal supply of power and no use for the surplus, to the present condition in which the expenditure of every thermal unit is watched with a jealous eye, occurred simultaneously with the development of the steam boiler from the relatively crude types, which I have described, and which were in practically universal use at one time in all other industries as well as at the blast furnace, into the modern water-tube types. First came the single-flue and two-flue boilers, then through a gradual increase in the number and decrease in the size of the flues, the multitubular boiler, which was for so many years the standard in good steam practice. Then came the later evolution, forced by rising steam pressures from the horizontal tubular boiler to the water-tube boiler, which became well established about the time the demand for more economical boilers for blast furnaces developed.

In this way blast furnaces skipped that period of development during which the horizontal tubular reigned supreme in most industries, and passed immediately from the cruder types to the modern water-tube boiler.

Horizontal Tubular Boilers

At the Illinois Steel Works in South Chicago, where coal was expensive as compared with Pittsburgh, and where a furnace plant and steel mill were early operated in conjunction, they used at one time a great number of horizontal tubular boilers; but this is the only large blast-furnace plant, to my knowledge, where extensive use was ever made of this type of boiler. These have now all been superseded by water-tube boilers.

In New England, where fuel is expensive and where the textile mills use in the aggregate almost as much power as do the steel mills of the country so that their operators have been forced to use every possible economy in steam generation and utilization, they continue to use the horizontal tubular boiler to a great extent, even down to the present time.

It is, therefore, not on the ground of economy that this boiler has been driven out, but rather by two demands of modern practice which jointly have set conditions impossible for it to meet. These two conditions are, first, increasing steam pressure; second, a demand for large individual units so as to keep down as low as possible the total number of units for large powers. Both these conditions require heavier shells for horizontal tubular boilers, and these being exposed to the direct action of the fire their safe thickness is limited to that which will permit the cooling effect on the inside to prevent the rapid burning or cutting away of the outside, particularly at the seam with its double thickness and projecting rivets.

Water cooling is effective against the direct action of fire only within certain definite limits of thickness, and these are approximately reached in the horizontal tubular boiler at a capacity of 300 horsepower and a pressure of 125 lb. to the square inch, and though by special construction these conditions have been exceeded in horizontal tubular boilers of this type, this pressure is lower than that demanded by modern practice, and the units are smaller than is desirable in large plants. Hence the horizontal tubular boiler is eliminated from the competition.

Moreover, the question of safety is always to be considered, and while it is by no means to be thought that water-tube boilers are free from accidents, it must be admitted that the consequences of such accidents are probably on the average less destructive to life and property than those of horizontal tubular boilers.

Types of Water-Tube Boilers

The number of types of water-tube boilers which have been introduced in the last twenty or thirty years is literally legion. Many, if not most of them, have been applied from time to time and from place to place, in blast-furnace service. Many of them are still in such service. But the development of modern plants has settled down to the use of half a dozen types, of which we may consider four.

Before proceeding to a description of these, however, a general review of the conditions of operation of boilers at blast furnace plants will not be amiss. These differ in some respects from those prevailing in ordinary insallations. First, they are normally gas-fired, though provision is always made for the use of coal should it become necessary. Second, the furnace gas with which they are fired generally contains a considerable quantity of dust which settles on the tubes and heating surfaces, and rapidly impairs their conducting power, if not removed. Third, the boilers are operated twenty-four hours a day and seven days a week. There is no stoppage of the plant over Sunday as is customary in other industries during which the boilers can be cleaned, and for this reason a sufficient reserve of boiler power must be installed to allow at least one unit to be constantly out of service for cleaning. Other than these, the conditions do not differ materially from those of economical boiler operation in general.

General Considerations Concerning Water-Tube Boilers

The first and most important condition is, of course, that the tubes must be kept clean, not only externally but internally, and until very recent years it was practically impossible to do this in any except perfectly straight tubes. This is no longer true, but at the same time straight tubes are greatly to be preferred to curved ones, as they are less expensive and generally far less troublesome to replace than curved tubes, and in everything except length are interchangeable, which cannot be the case when curved tubes are used.

Owing to the nature of hydrostatic pressure, any vessel subject to such pressure tends to become circular, and if any other form than this is used in order to resist deformation it must be given greater strength than would be required by the circular form in a proportion greater than its deviation from the latter. For this reason flat, parallel surfaces on upper and lower drums, until recently the only ones between which straight tubes could pass, have been frowned upon by boiler insurance companies and boiler inspectors, particularly during recent years when pressures have risen far beyond what they were ten years ago, because of the difficulty of staying such flat surfaces so that they will stay flat, and the liability to excessive stresses and leakage, and even failure if they distort under pressure.

Moreover, it was for a long time very desirable to have the tubes not only straight, but to have them so set that their ends could be exposed and a cleaner carried by a rigid rod a little longer than the tube,

inserted and driven through. This could not be done if the tubes were set in drums, because the drum would prevent the entrance of a cleaner so mounted into the tube. Therefore, two of the most successful of the earlier types of boilers had parallel water legs depending from opposite ends of a combined steam and water drum above, and from one of these water legs to the other ran the straight tubes. The water legs could obviously not be circular in shape and yet permit the use of straight tubes, so

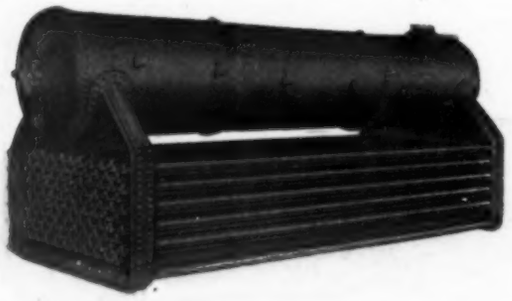


FIG. 1—THE HEINE BOILER WITHOUT ITS SETTING

they were made in various ways to give the necessary strength and access to the tube ends, and at the same time permit the use of straight tubes.

One of the types of boilers on this general plan is the "Heine," built by the Heine Safety Boiler Company, and illustrated in Figs. 1 and 2. Fig. 1 shows the construction of the boiler independent of its setting. The water legs are made of flat plates stayed together by screw stays, as in locomotive-boiler construction, the perfectly flat parallel surfaces lending themselves to safe and adequate staying better than any other shape. The inner surfaces of the water legs act as the tube sheets, while holes a trifle larger than the tubes are cut through the outer surface of

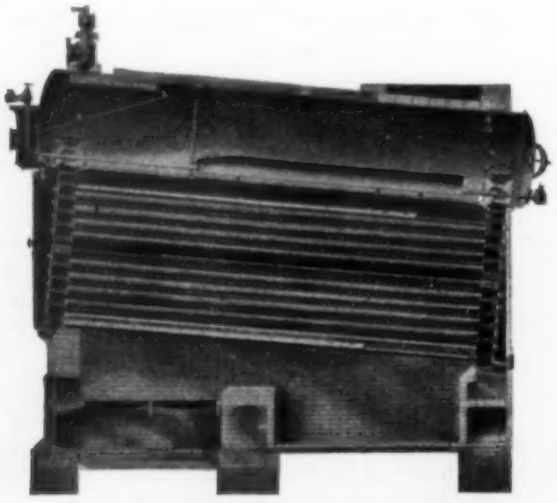


FIG. 2—THE HEINE BOILER IN ITS SETTING

the water legs exactly in line with these. These outer holes are closed when the boiler is in operation with a hand-hole plate, dog and bolt, but when the tubes are to be cleaned or removed these hand-hole plates are removed and give free access to the ends of the tubes.

The screw stays should be called stay tubes and not stay bolts, because each of them contains a hole large enough to permit the entrance of a half-inch pipe with a steam jet on the end, and as these stay-tubes are in the center of the space between the water tubes this permits the steam jet to pass down between the latter from end to end, and thus effectively blow the dust off one-fourth of each of the four surrounding the space.

This is necessary with boilers in all industries, but is particularly necessary at blast furnaces because of the great quantity of fine dust carried by the gas at the majority of plants.

The boiler in its setting is shown in Fig. 2, which also shows the baffling. It will be seen that the gases go to the rear, then to the front, and then to the rear again, passing around the drum on their way to the stack. For this reason the drum is covered with fire brick above the water line, and this is very important because I have seen the drums of this type of boiler badly burnt through failure to keep these covering bricks in place.

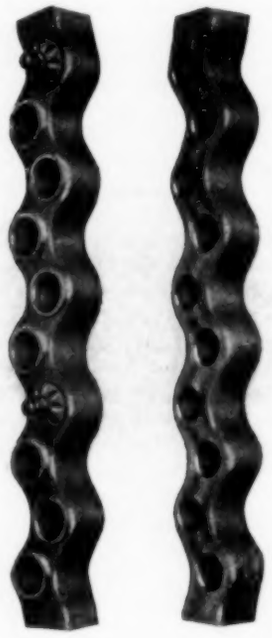


FIG. 3—WROUGHT STEEL INCLINED HEADER

Fig. 2 shows a boiler adapted only for the burning of coal, but only two minor changes are required to adapt it to burning furnace gas also. First, it should be set a little higher above the grate, and a burner opening should be provided through the front wall between the bottom of the water leg and the top of the fire arch. Second, the tiles used as baffling immediately over the fire should be of the type which completely surrounds the tubes, covering their lower as well as their upper surface, as such tiling constitutes a water-cooled fire arch. The tiles become hot enough to permit combustion, whereas the relatively cold tubes kill down the flame before the gas and air have a chance to mix sufficiently to produce complete combustion. When such gas has once been extinguished it will not reignite, but passes out of the stack unburnt and represents a dead loss.

The Babcock & Wilcox Boiler

This boiler differs from the Heine principally in having the water leg subdivided into as many sec-

FIG. 4—FORGED STEEL CROSS BOX

tions as there are vertical rows of tubes, this being a still further extension of the sectional idea for localizing and minimizing the effect of failure of any part. As the arrangement of the tubes in a vertical plane is staggered these headers are made sinuous, as shown in Fig. 3.

Each of these headers is connected to a saddle or cross-box riveted to the drum, by means of straight tubes expanded into the top of the header at one end and into the bottom of the cross-box at the other. The cross-boxes are shown by Fig. 4.

The boiler as a whole is well shown by Fig. 5. This boiler is suspended from a structural steel frame instead of being supported directly on the brick, as is the case in the Heine boiler. Another difference from the latter boiler is that in this case the passes

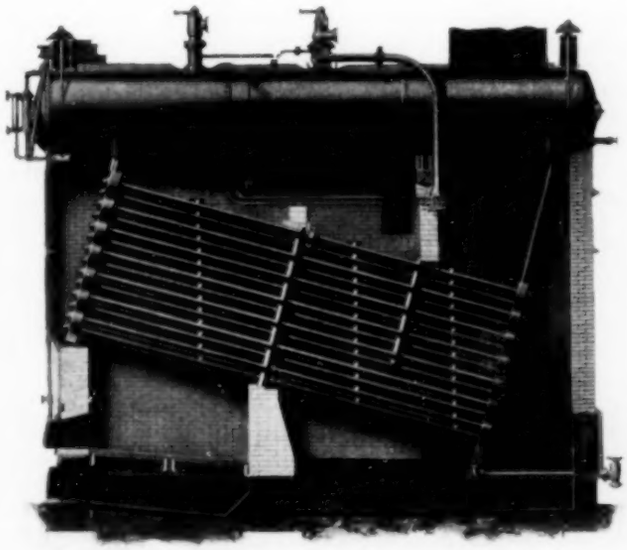


FIG. 5—BABCOCK & WILCOX BOILER IN SETTING

are at right angles to the line of the tubes instead of parallel with them.

The baffles are built up of fire brick supported by clamps around the tubes. These fire bricks make a continuous wall with the tubes passing through it, and supporting it. One of these walls run up from the lower bridge wall, the other comes down from the suspended upper bridge wall, the passage of the gases being first up, then down, and then up again, either out above, or through the suspension tubes of the rear headers, and into an underground flue.

The arrangement of having the gas pass off upward is very much to be preferred to that in which it passes downward because the latter involves the use of underground flues, and when these become obstructed by dust as they ordinarily do in the course of a few months run, they can in general only be cleaned by shutting down the plant and putting men into them to shovel them out. In some cases the arrangement is such that a heavy stream of water can be turned into the flue and the dust washed out with this, but even this arrangement is inferior to the overhead flue, which can be provided with dust pockets through which the dust can be drawn into carts or wheelbarrows before it accumulates to an objectionable extent, and without any interruption to operation.

The boiler here shown is equipped with a superheater, this being the U-shaped coil lying on its side in the space between the bottom of the drum and the top of the water tubes. Super-heaters, as far as I know, have never ben used in blast-furnace practice, probably for the reason that they have the reputation of requiring a good deal of maintenance, and a correspondingly large number of interruptions to service, both of which would go far to offset any advantage they might produce in steam economy, interruptions to continuous service being particularly objectionable.

These boilers can be arranged for a gas firing exactly as described for the Heine, by the introduction of a gas burner immediately above the fire door, but my preference is strongly in favor of the use of a combustion chamber for burning furnace gas, and as the tiles surrounding the tubes cannot be used in this boiler because they would cut off the passage of the gas and flame completely, I am strongly in favor of the use of a Dutch oven in front of these boilers when they are to be fired with furnace gas.

Such a Dutch oven will be described and illustrated in connection with the Rust boiler, and, therefore, need not be described in detail here. In order to apply it successfully the boiler generally requires to be set somewhat higher than when no Dutch oven is used, but this is a matter of slight cost and no subsequent disadvantage.

The sinuous headers fit into each other very closely and no opportunity is permitted to introduce a steam jet longitudinally between the tubes. Consequently, in order to permit these boilers to be blown off three sets of blow-off doors are provided whose location is indicated by the three vertical rows of white dots between the tubes in the illustration. The brick-

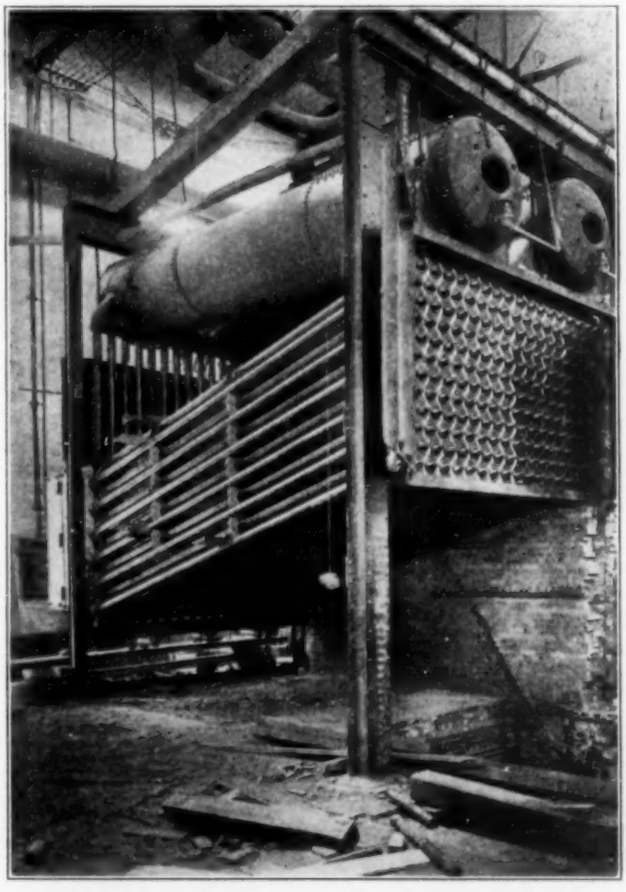


FIG. 5A—BABCOCK & WILCOX BOILER IN COURSE OF ERECTION SHOWING HOW HEATERS FIT INTO ONE

work is cut away from these doors at an angle of 45 degrees on each side, and individual blow-off holes are provided opposite the space between each two rows of tubes. By this arrangement a steam jet can be inserted between each pair of horizontal rows and also above the top one, and swung through a wide angle. By doing this from both sides the dust may be blown from the tubes quite effectively.

The headers are provided with holes in each side exactly like the water legs of the Heine boiler, the outside one being covered by a cap, held to place against the pressure of the steam with a bolt pulling

against an inside dog. This puts the joint on the outside of the header, and these are all ground so that a metal-to-metal joint can be made.

These caps give access to the inside of the tubes for cleaning exactly as in the Heine boiler, and like it at the expense of two hand-hole joints to make for each tube, to which some operators object on account of the pains necessary to keep these joints in good

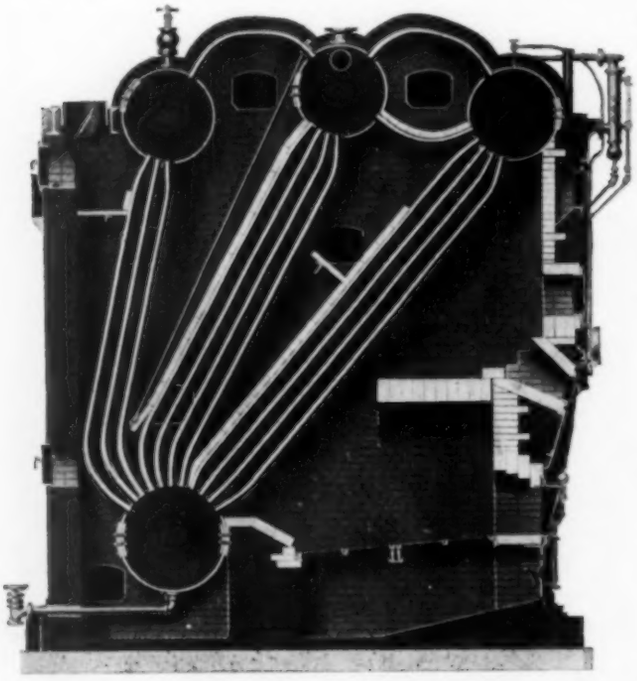


FIG. 6—STIRLING BOILER IN SETTING

order, although if they are made thoroughly tight before the boiler starts up they seldom give trouble in operation.

The Stirling Boiler

This boiler and its setting are both clearly shown in Fig. 6. This boiler is of an entirely different type from both the two preceding ones in two important particulars. First, there are no headers but three circular drums above and one below. From each of these three a set of tubes run to the lower one. Second, as the tubes all enter the drums radially they are necessarily curved at their ends to a greater or to less extent.

This construction eliminates the header altogether, but introduces the curved tube, and also cuts off access to the tube with a bar or cleaner of any type except a flexible one.

This for many years was the most serious obstacle to the continued successful operation of these boilers. They were furnished with scrapers mounted on chains with a weight on the end, this weight was dropped through each tube in turn and the scraper then pulled through after it. It will be seen that this was an exceedingly laborious operation, particularly as the drums are small, only 3 to 4 feet in diameter, and men could consequently only work lying down or crouched very low. The air in these drums is generally not of the best and the slightest leak of hot water from the steam connections above, or the blow-off below, makes them an almost intolerable place in which to do any work, especially the violent physical labor involved in hand-scraping.

These conditions have been very much changed by the introduction of power cleaners, which we will describe briefly at the end of this chapter.

The baffling in these boilers is inclined, but follows the line of the batteries of the tubes running to the different drums. The course of the gases is up, down, and then up through the stack connection to the draft opening just back of the rear drum. Three ordinary cleaning doors are provided above and one below, through which a steam jet can be introduced into the setting and the dust blown from the tubes, but owing to the steep angle at which the latter stand dust has not ordinarily the same tendency to settle upon them that it does on tubes that are approximately horizontal.

The bottom drum serves as a mud drum, and the sediment concentrated by the evaporation of the water gathers there, at least in part, and is blown off through the blow-off valve.

The feed takes place in the rear drum above which is entirely filled with water, and from there the feed water passes forward to the second and finally to the forward drum, there being a set of water tubes below the water line, and also steam tubes above it, connecting the front and middle drums, which serve as steam drums, particularly the middle one.

The setting of this boiler is regularly provided with a partial combustion chamber, and, therefore furnace gases may be burnt under it by introducing the burner immediately above the fire-door, but for best results with furnace gases the setting should be modified by throwing its lower part forward so that the combustion chamber would be longer.

As between the Stirling and the Babcock & Wilcox boiler some prefer the Babcock on account of its straight tubes and ease of cleaning, while others prefer the Stirling, claiming that it gives drier steam, and because it does not have a multiplicity of hand-hole plates to put on, take off, and keep tight.

The Rust Boiler

This is the latest developed of any boiler in extensive modern use. It was invented to solve what had seemed for many years an insolvable problem, that of making a boiler containing nothing but straight tubes, and yet using only circular drums. This seemed impossible, because it is necessary for the tubes to enter the drum radially in all the older constructions, and this means that all the tubes except one row must be bent to reach this direction, as is clearly shown by the illustration of the Stirling boiler.

Mr. E. G. Rust, then chief engineer and later gen-

FIG. 7—RUST TUBE SHEET

eral superintendent of the Colorado Fuel & Iron Company, overcame this difficulty by making a forged steel tube sheet for the drum, which was circular in its principal section, but which had forged into it cup-like depressions whose axis was not radial to the drum, but in the line which the tubes were desired to have. This is shown by Fig. 7. These tube sheets are made of sufficiently heavy material so that even after the drawing necessary to form these pockets the material is amply strong.

The boiler in its setting is well shown by Fig. 8. It consists of four drums, two below and two vertically above, connected by five rows of straight vertical

tubes. A bridge wall extends up from the foundation between the two elements of the boiler. The flame comes in on one side, passes vertically up, surrounding one nest of tubes, over the bridge wall and down, surrounding the other, thence to the stack. The

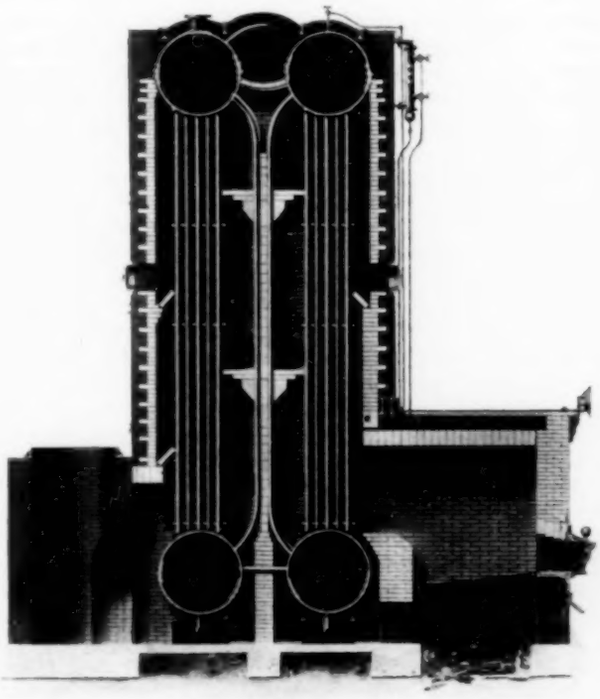


FIG. 8—RUST BOILER IN SETTING

bottom drums are connected by a single row of straight tubes, the top drums by an upwardly curved set of tubes for steam, and a downwardly curved set for water, the latter carrying baffle tiles to keep flame out of contact with the drums above the water line.

One of the advantages claimed for this boiler is that the tubes being set vertically the dust has a minimum tendency to adhere to them, nevertheless three horizontal blow-off doors are provided which are of the same type as those described for the Babcock & Wilcox boiler, but set horizontally in this case so as to be at right angles to the line of the tubes. The setting of this boiler precludes the possibility of having the flame burn directly upward against the tubes, and owing to this construction a Dutch oven must be provided even with coal firing, which makes its adaptation to blast furnace gas very easy.

Fig. 9 shows the front of the battery of these boilers equipped with gas burners above the fire doors. The gas main may be seen in the upper right-hand corner of the illustration, and its connections to the individual pairs of burners. The valves controlling them, operated by wheel and hand-chain, are also shown.

It seems no more than fair to say that these boilers are generally preferred by blast-furnace managers who have used them above any other type.

Gas Burners for Boilers

Blast-furnace gas is a relatively lean gas. When of the normal composition given above it requires about 60 per cent of its own volume of air for theoretically complete combustion, to which a small excess is generally added because while the losses from heavy excess of air are very great, those from unburnt combustible are still greater, and as it is impossible to maintain an absolute adjustment of air to gas it is better to err on the side of having a small excess of air rather than any considerable quantity of unburnt fuel.

In order to get the best results with the least excess of air an intimate mixture of gas and air must be made, and as the velocity of the gas through the boilers under the effect of draught is high the time for making this mixture is limited to a small fraction of a second. For this reason the entering currents of gas and air must not only be in intimate contact, but must present a maximum surface of contact for the area of opening required. This result is obtained either by the use of multiple ports for gas with air ports between, or by the use of a narrow port for gas with air on both sides. The latter is the type shown in Fig. 9.

The end of the curved flat burner projects into the front of the fire box with a clear space for air all around it. By the simple expedient of having a rectangular frame surrounding the burner and sliding on it, which can be pushed up close to the fire box front or drawn away as desired, the amount of air admitted may be varied at will, while the amount of gas may be controlled by the gas valve above. This provides independent regulation of air and gas, admitted to be a prime necessity for the most economical combustion of furnace gas.

In former times gas flues from the furnace to the

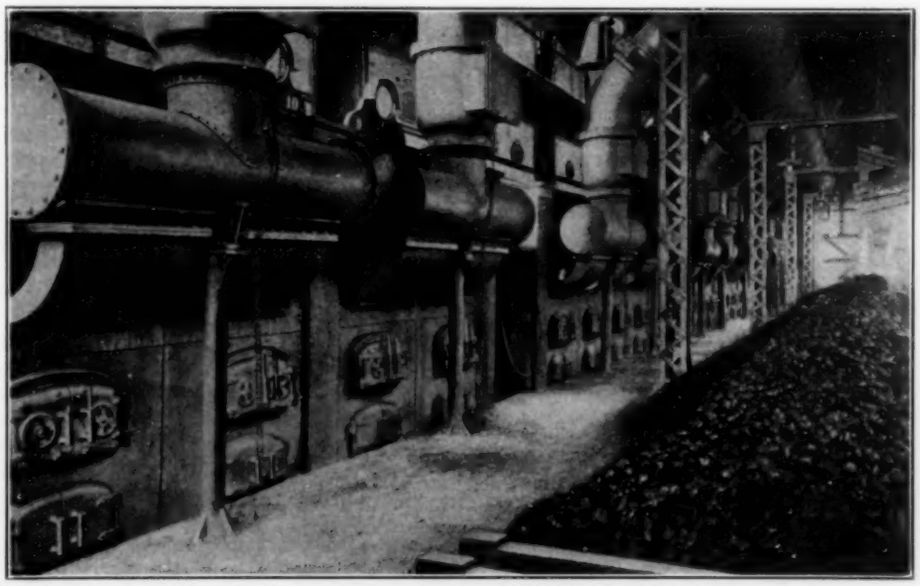


FIG. 9—SHOWING BURNERS FOR BLAST FURNACE GAS

boilers generally ran underground, and in these cases the burners were arranged to stand over an opening in the top of this flue. But such flues are unsatisfactory, both because of the difficulty of cleaning them out, which is still greater than that in the case

of the chimney flues, and because being under the ground their tightness can never be insured, nor the amount of leakage from them determined, and leakage of furnace gas is not to be tolerated because only a few cubic feet in a large room are necessary to cause sickness and violent headaches, if not more serious consequences. Therefore, overhead mains of steel generally lined with fire brick are now commonly used, and the burners are suspended from them in some such way as that illustrated. This is a decided advantage, not only for the reasons given but because the burner is completely above and out of the way of the fire doors in case coal firing is necessary, which is by no means the case with burners coming up from below, which are not infrequently in the way at such times.

Precautions as to Grates

When a Dutch oven or combustion chamber such as I have recommended is used the radiation from its roof or top surface is intense, while the grates are not protected by a current of air up through them as they are when coal is burned, since the air must be admitted with the gas for reasons explained above, and, therefore the ash-pit or draught doors must be kept closed.

For this reason the grates should be lightly covered with some substance such as coal, ashes or even a layer of brick laid loosely over them, to cut off the heat from above, otherwise the radiation from the arch is liable to melt them down or at least fuse shut the air openings. This would not be observed as long as the gas supply continued, but if in an emergency it suddenly became desirable to fire coal the grates being worthless none could be burned, and serious delay would result as well as the loss of the grates.

Very frequently the grates are protected by having a bed of coal spread on them which burns very slowly because no air comes up through it, the hot upper surface of which serves to light the gas instantly if the supply should fail momentarily and then start again. This is a matter of much importance, because if a mixture of gas and air fills the setting before ignition an explosion will result when ignition takes place, and the setting at least will be seriously damaged, even though the boilers are not thrown out of place and they or their steam connections ruptured. Accidents of this kind have frequently occurred, and too many precautions cannot be taken to avoid them.

Boiler Cleaning

I have already described the earlier and cruder methods of cleaning water-tube boilers. It is not too much to say that these methods were so ineffective and the difficulty of keeping the tubes of these boilers in condition was so great that it seriously retarded the introduction of this type of boiler, because it must not be ignored that when a deposit of scale is formed inside of a tube it is reasonably secure from molestation even though the tube be taken out of the boiler bodily, so that tubes could not be cut out, cleaned off, welded up, and put back, practically as good as new, as is easily possible with the horizontal tubular boiler. This is so serious a consideration that the writer on one occasion needing additional boiler capacity installed a horizontal tubular boiler rather than contend with the difficulties of cleaning the water tube type.

In more recent years these conditions have been greatly improved for the water-tube boiler in two ways.

First, by the very general introduction at large plants which do not possess a natural supply of good boiler water, of purifying plants which neutralize any injurious acid which the feed water may contain (which in coal mining regions is sometimes a very large quantity), and then, by the addition of some suitable chemicals, precipitate out a large part of the scale forming material which the water contains, and throw that which is left into a form which makes sludge and can be blown out. Without such treatment this material settles on the tubes and other heating surfaces in a deposit almost as hard as iron, and almost as non-conducting as asbestos.

Second, by the introduction of power-driven boiler cleaners of various types. Generally the power is transmitted to the cleaner, either by water under pressure or by compressed air, the fluid under pressure in either case drives a motor of a size small enough to go inside the tube and pass through it freely. This motor carries at its forward end steel cutters of various forms, generally loosely pivoted to the shaft of the motor and thrown out to the wall of the tube by centrifugal force.

The motor is run at a very high speed and the rapid whirling of these cutters removes the scale which is carried out of the tube by the "exhaust" of the fluid which drives the motor.

Much ingenuity has been employed both in making and in selling devices of this kind, and some of them are extremely meritorious. The motors in general are of two types, turbine and sliding vane positive-pressure motors. It would be thought that this would be the ideal field for the turbine but I have obtained the best results with the sliding vane positive-pressure motor.

As between the two fluids, water and air, the advantages, in my judgment, are so strongly in favor of compressed air as to put it beyond comparison. This is for two or three reasons. First, the men working with the apparatus are at close quarters with it in a confined space, and no matter how carefully made and operated water-driven apparatus may be under such circumstances, it is impossible for the operator to avoid becoming wet and very dirty from the sludge produced by the grinding up of the scale. This makes the task an excessively disagreeable one for the operator, and reduces his speed in working at it materially. Secondly, the exhaust water from the motor cannot be prevented from reaching the brick work of the setting to a greater or less extent, and in the Babcock and Wilcox boiler it is almost impossible to prevent its running down into the underground flue with a bad effect upon both the draught and the flue.

With air none of these disadvantages exist. The air is perfectly clean, and its expansion even tends to cool to a small extent the air in the drums which the operator has to breathe, so actually ameliorating the conditions under which he has to work, while, of course, it has no effect whatever on the setting. Moreover, the amount of power needed may be transmitted through a much smaller hose with compressed air than with water, and, therefore the hose which connects the motor with the supply of power, and by which it is pushed through the tubes, is correspondingly smaller, lighter and easier for the operator to handle.

By the use of the best types of these cleaners boiler tubes can be kept clean at a fraction of the expense and with a fraction of the time lost from service that are required when hand-cleaning is used.

Moreover, it is very much to be doubted whether hand-cleaning ever cleans the tubes so thoroughly as

do power cleaners no matter how conscientiously the former may be done.

I have seen the power cleaner applied to boilers supplied with the best natural feed water which had received the most thorough care, were thought to be absolutely clean, and were as far as could be seen, but at certain points the cleaner found and removed scale a quarter inch or more in thickness, which had been entirely invisible from the ends, although these were straight tubes.

Owing to the short length of these cleaners they may be used on curved tubes as well as straight ones and are equally effective therein.

This goes far to remove the disadvantage under which the Stirling and other curved-tube boilers formerly labored and to put them on a parity from an operating point of view with the straight-tube types. Of course, this does not remove their disadvantage in the matter of removing and replacing tubes.

The power boiler cleaner is like many other useful tools in that it must be used with care and discretion.

In order to cut the scale the cutters must be good tool steel, almost as hard as glass and very sharp. In order to be effective they must run at a speed of many hundred revolutions per minute. It is obvious that if allowed to run in contact with the bare tube in one place they would soon cut it away enough to weaken it seriously if not to cut it through entirely, and the operator must be carefully instructed and advised to prevent this.

These two developments of the past decade and a half—the feed-water purifying plant which keeps out of the boilers much of the scale-forming material, and the power-drive tube cleaner which removes that which gets in—have reduced to a fraction of their former amounts the time, labor and expense of boiler maintenance, increased their average efficiency and decreased the percentage of spares necessary. They have thus gone far to solve the problems of boiler operation at blast furnaces.

Notes on Chemistry and Metallurgy in Great Britain

(By Our Special Correspondent)

Oil Shale in Skye

The shale deposits in the Isiand of Skye, which were described in a recent letter, have been further examined by boring, and although the shale thus obtained shows a considerably higher value than the samples taken when the announcement of the discovery was made last August, yet they are not rich enough to warrant the hope that the deposits can be worked profitably at present. The specimens taken in August were obtained from very badly weathered outcrops, and, of course, showed a very poor oil content. Lord Macdonald, the owner of the island, consequently had five borings made, and the samples from these show a yield of only some 19 gallons per ton—a result which can only be considered disappointing in view of the fact that in the Lothians a paying shale would produce quite 30 gallons per ton. It is possible, however, that some portions of the deposits in Skye may be of a better quality, and it is expected that further investigations will be made.

Corrosion of Iron and Steel

Mr. F. Crosby-Jones recently read a paper before the Institute of Mining Engineers on "The Corrosion of Iron and Steel," and while he did not contribute anything new to the various theories of the cause and nature of corrosion, he made some valuable suggestions as to the practical methods of prevention of corrosion. He advocated that the same class of metal should be employed throughout all structures as far as possible, and that surfaces should be rendered smooth and without any depressions, pockets or cracks, which would be capable of retaining water. Free access of air to all members should be provided, and arrangements should be made for any necessary drainage of water. Special attention should be given to joints, rivet-heads, nuts and bolts to effect complete exclusion of wet and moisture, while a most careful inspection of all parts which were not easily visible was most essential. With regard to painting, inspection would be much facilitated by having each coat of a different shade, and a check could be more easily kept on the number of coats supplied. Perhaps the most important point was that the metal should be thoroughly cleansed and dried before any protective coating was put on, and even then it was necessary to employ a good and suitable material and to insure that the work was efficiently done.

The Progress of the Electric Furnace

It has been generally supposed that British smelters and refiners have shown considerable reluctance to adopt the electric furnace, but statistics go to show that after all they have not lagged very much behind other countries. There are now 14 electric furnaces at work in England, 13 in France, 20 in Italy, 17 in the United States and 32 in Germany, besides a few in other countries, making a total for the world of something between 140 and 150. A remarkable fact is that in Germany 50 per cent of the furnaces are of the induction type and 50 per cent of the arc type. Out of the 20 Italian furnaces 19 are arc, as are 10 out of the total 13 French, and 13 out of the 14 English. The Heroult, the Girod, and the Stassano are the arc furnaces most numerously adopted, while the Kjellin and the Röchling-Rodenhäuser occur most frequently in the induction installations. The progress in Scandinavia is shown by the fact that Norway and Sweden employed only nine furnaces for the smelting of pig iron in 1912, and had more than doubled the number by the end of the following year, when 20 furnaces were in full operation.

The Institution of Mining and Metallurgy

On the 13th of January the Institution of Mining and Metallurgy entered into possession of its recently acquired premises in Finsbury Circus, when the Lord Mayor performed the opening ceremony on the 22nd anniversary of the foundation of the institute. The membership has risen from 585 in 1899 to 2372 last year, and for some years the necessity of finding more extensive accommodation than was afforded by the old headquarters at Salisbury House has been increasingly apparent; but it is not always easy to find suitable premises in just the locality of the city in which the mining industry predominates. The building has been entirely renovated throughout, but the main architectural features have been interfered with as little as possible. The president, in calling on the Lord Mayor to open the building, said he wished to remind his hearers that practical metallurgy was very largely represented in London by extensive refining of gold and silver. The weight of gold melted at the Royal Mint and some other refineries amounted to 508 tons in 1812, and London was still in the proud position of being the only free market in the world for gold. It was their intention to present a petition to the King for a Royal Charter of incorporation by which the corporate existence of the members as metal miners and metallurgists would be recognized. The Lord

Mayor was then presented with a gold key, the wards of which were fashioned from the institution's initials.

The Absorption of Gases by Celluloid

At the December meeting of the Chemical Society Mr. Victor Lefebure read a paper in which he stated that he had observed in celluloid an absorption of gases comparable with the absorption of gases by some kinds of charcoal. The effect was of the reversible order, and was not chemical because there was not any formation of a compound with a very low or moderately large dissociation pressure—it being assumed that such compounds would not form solid solutions with celluloid. The absorption occurred with all varieties of celluloid examined and reached a minimum in the case of a precipitate of celluloid constituents; but when this precipitate was reformed into a film the absorptive property recurred. The two chief constitutents of celluloid, nitro-cellulose and camphor, do not exhibit absorption. The effect was inversely as the temperature and directly as the pressure; and, in its general nature resembled a case of sorption. Diffusion experiments have established the fact of diffusion through films.

Professor Donnan, in the discussion, said that the rapidity of the initial absorption of carbon dioxide and the fact that the increase of the speed of absorption per unit weight of celluloid was greater than the increase of surface went to show that there was in the body of the celluloid—perhaps near the surface—a very fine-grained macro-porosity into which the gas could readily penetrate and be there absorbed.

Mr. W. P. Dreaper remarked that the porosity of structureless cellulose filaments could be widely varied by varying the strain to which they were subjected during the drying process of their manufacture.

A Substitute for Petrol

Professor Vernon Boys, the well-known authority on gas-work chemistry and engineering, has devised and carried out a process for the commercial production of motor-spirit from heavy mineral oil waste, and states that the product is at least equal to ordinary petrol as fuel for motor engines. The heavy waste, heated to a fixed temperature, is subjected to the intimate action of steam, at 315 deg. C., which is then circulated through heated tubes containing a series of nickel rods. Hydrogen is liberated from the steam and combines with the finely divided particles of oil forming a substance closely resembling natural light petroleum spirit or "ligroin." The process is said to yield over 40 per cent of spirit from the crude waste: and the gaseous hydrocarbons which are also produced can be used for heating the tubes containing the nickel rods. A tarry residue remains and is available for further treatment or for other uses; and possibly—provided that a sufficient supply of waste oil were obtainable—the recovery of by-products might become worth attention.

The Prevention of Scale in Boilers

A new device has been brought out under the name of the Vapor Scale Collector for which a high degree of efficiency is claimed in removing from the feed water those dissolved substances which under ordinary conditions contribute largely to the formation of scale.

The apparatus is simple, and consists of a series of partially perforated trays divided into compartments fixed in the steam space of the boiler and arranged so that the feed water passes in a cascade from the top tray to the bottom one with a wavy motion and at a rate which insures its attaining a temperature of 300 deg. F. before reaching the boiler water, when the feed is continuous and the boiler pressure not less than 85 lb. per square inch.

At this temperature carbon dioxide and dissolved air are completely expelled from the water, and a very large proportion of the scale-forming solids usually found in ordinary waters is deposited in the trays as mud and under them as stalactites. But, of course, most of the calcium sulphate, which goes to form hard scale, would not be thrown out of solution.

Engineering Imports and Exports

The returns issued by the Board of Trade for the twelve months ended on December 31, 1913, show a very substantial improvement on the figures for 1912 in all classes of engineering materials and manufactures, especially with regard to exports. Imports of iron and steel, including manufactures, amounted to £15,230,694, an increase of £2,268,703, and exports totalled £54,328,292, an increase of £5,730,615. Other metals, including manufactures, were imported to the value of £32,102,246, a rise of £904,818, and were exported to the value of £13,288,350, an improvement of £1,003,879. Imports of electrical goods reached £1,587,318, and exports £5,404,671; the respective increases being £129,675 and £1,063,084. In machinery the imports were £7,282,046, a gain of £461,363; and exports went up to £37,027,582, which is a rise of £3,869,567.

The figures for the month of December alone are not so satisfactory. Imports of iron and steel increased by £208,139 on the value for December, 1912; but exports were £229,874 lower; imports of other metals fell £497,704, and exports decreased £126,979; imports of electrical goods rose £18,083, and exports were £26,345 higher; imports of machinery were only £3265 better, while exports improved by £214,122; new ships rose £1,171 in imports, but exports declined £394,484.

Market Prices

January, 1914

	£ s. d.
Aluminium ingots, in ton lots	90. 0. 0
Alum, lump, loose, ton	5.10. 0
Antimony, Star Regulus, ton	£28 to 30. 0. 0
Borax, British refined crystal, ton	17.10. 0
Copper sulphate, ton	22.10. 0
Caustic soda, 70%, ton	10. 5. 0
Copper ore, 10 to 25%, unit	11/ to 11. 6
Ebonite rod, lb	4. 6
Hydrochloric acid, cwt	5. 0
India-rubber, Para, fine, lb	3. 2½
Mica, in original cases, medium	3/6 to 6. 0
Petroleum, Russian spot, gal	9¼
Quicksilver (Spanish) bottle	7.10. 0
Sal ammoniac, cwt	2. 2. 0
Sulphate of ammonia, ton	12.10. 0
Sulphur, recovered, ton	5.10. 0
Shellac, cwt	4. 2. 0
Platinum, oz., nominal	9. 5. 0
Tin ore, 70% ton	£103 to £105
Zinc, Vielle Montagne, ton	25. 0. 0

Higher	£ s. d.	*Lower*	£ s. d.
Tin, ton	10. 0. 0	Borax, ton	1. 0. 0
Scotch pig	7½	Sulphate of ammonia	10. 0
Cleveland	9½	Shellac, cwt	6
Lead	2. 0. 0	Zinc, ton	12. 6
Ebonite rod	6		

Copper opened £64 10s. 0d. and declined till the 9th, when it had reached £62 17s. 6d., recovering slightly on the 12th, it afterwards fell slowly, reaching £62 12s. 6d. on the 14th, and then recovered, rising until £65 7d. 6s. was touched on the 23d, and £66 on the 30th.

Tin opened £168 and fell away smartly to £166 10s. 0d. on the 5th, recovered on the 6th to £168 10s. 0d., and was £167 on the 8th and £167 5s. 0d. on the 14th, with recovery between. From the 15th, however, it became stronger, rising to £173 7s. 6d on the 21st and £177 on the 22d; the 23d saw a drop to £174 10s. 0d., and its subsequent recovery to £176 15s. 0d. on the 26th and £180 on the 30th.

Symposium on the Undeveloped Elements

Factors Involved in Opening Up the Field of Unused Elements—Papers on Cobalt, Boron, Ductile Tungsten, Selenium, Tellurium and Cadmium

The joint meeting of the New York sections of the American Electrochemical Society, the American Chemical Society, and the Society of Chemical Industry, held on the evening of Feb. 6 in the Chemists' Building in New York City, was exceedingly well attended in spite of the inclement weather. Mr. **Lawrence Addicks,** chairman of the New York section of the American Electrochemical Society, presided. The subject of the evening was a symposium of papers on "Undeveloped Elements."

Chairman Addicks in opening the meeting pointed out that "the number of known chemical elements is rapidly increasing and it is open to debate whether some of the brilliant work done in identifying new elements were not better applied to learn how to turn some of these already known to the use of mankind.

"In the earliest times we have the single conception of the unity of matter, which, strangely enough, we once in so often consider as still a possibility in explaining new discoveries. Then came the artificial classification of the early Indian and Greek philosophers, which were not rejected until shortly before the Christian era, at the beginning of which seven of the metallic elements were known—copper, silver, gold, tin, lead, iron, and mercury. The whole span of the middle ages and alchemy yielded but ten more elements, giving us a total of seventeen about 1750 at the beginning of Lavoisier's work. Sixty-seven elements were listed in Remsen's Chemistry of 1891. In the 1912 International Table there are eighty-two, and the end is not yet.

"Now I submit that a man's responsibility for an element should not end when he has proved his discovery by finding an atomic weight not already preempted and christened it with a name like a Pullman car, but that he should stay with it until he finds what it is good for. On the manufacturing side we have a similar situation. Many a concern will spend unlimited money to find just what substance will show certain desired properties, but, strangely, is unwilling to spend any money to develop uses for an apparently worthless by-product."

Mr. Addicks then introduced the first speaker, Dr. Charles Baskerville, who for years has made a special study of the less common elements and has conducted many researches along unused elements.

Factors Involved in Opening Up the Field of Unused Elements

Dr. **Charles Baskerville,** professor of chemistry and director of the laboratory of the College of the City of New York, introduced his paper by giving two convenient tables "confessedly imperfect and based on capricious opinion." In the first table elements are given which are little used or are not used at all, while their compounds are used more or less. In Table II elements are given which are unused or little used both as elements and compounds.

TABLE I.—ELEMENTS LITTLE USED OR NOT USED, BUT WHOSE COMPOUNDS ARE USED MORE OR LESS

0	1	2	3	4	5	6	7	8	Unclas.
	Li K	Mg Ca Ba Ra	B	S Zr Ce Th	AS		F Br I	Co	

TABLE II.—ELEMENTS OR COMPOUNDS UNUSED OR LITTLE USED

0	1	2	3	4	5	6	7	8	Unclas.
He Ne A Kr Xe Nt	Rb Cs	Be Sr	Sc Y La Ga In Er Tl	Ge	Cb Yb	Se Te		Ru Rh Os	Pr Nd Sm Eu Gd Dy Tm Lu Tb

About one-half of these have been discovered within the last thirty years. Those so recently made known are usually classified under the two groups of "rare gases" and "rare earths." The latter group is further conveniently subdivided under the heading of "rare earths" as follows:

TABLE III.—RARE EARTHS

Ce Group		Tb Group		Yt Group	
Element	Atomic Weight	Element	Atomic Weight	Element	Atomic Weight
Se	44.1	Eu	152.0	Dy	162.5
Yt	89.0	Gd	157.3	Ho	?
La	139.0	Tb	159.2	Er	167.4
Ce	140.25			Th	168.5
Pr	140.6			Yb	172.
Nd	144.3			Lu	174.
Sm	150.4				

Dr. Baskerville called attention to the melting points and specific gravities of four of them.

Melting points: Ce = 623 deg. C.; La = 810 deg. C.; Nd = 840 deg. C.; Pr = 940 deg. C.; Al = 660 deg. C., and Ag = 960 deg. C., which gives a standard of comparison.

Specific gravities: La = 6.15, Pr = 6.48, Nd = 6.96, Ce = 7.04.

"Cerium has about the same density as Sn (7.3), but all of them readily oxidize on exposure to air. Cerium is between lead and tin in its physical appearance and harder than tin, while lanthanum acts much like metallic calcium, its oxide combining readily with water to form the hydroxide, being even air slacked (combining with carbon dioxide) as does lime." Dr. Baskerville exhibited small samples of these metals prepared in his laboratory, and in passing stated that the price of metallic cerium in Germany has fallen from 250 to 20 marks per kilo.

"The word 'rare' as applied above—as is the case with so many words of qualification—has changed its meaning in the light of very recent investigations, although the 'rare gases' are found in the atmosphere in the following proportions:

TABLE IV.—NOBLE GASES

Name	Atomic Weight	One Part by Volume in Air
Helium	4.0	2,450 volumes
Neon	20.	808 "
Argon	39.9	105 "
Krypton	81.8	746,000 "
Xenon	128.0	3,846,000 "

"Some of the elements mentioned above are by no means so uncommon now and may be had in commercial quantities." Table V contains these and some

other elements, many of which have been known for a long time, not now used extensively, but inviting application.

TABLE V.—ELEMENTS NOW AVAILABLE, OR EASILY RENDERED AVAILABLE, IN COMMERCIAL QUANTITIES, BUT LITTLE USED

0	1	2	3	4	5	6	7	8	Unclas.
A	K	Ca Sr Ba Cd	B Y La	Si Zr Ce Th	As Cb Ta	Se Te	Br I	CO Pd	

FACTORS INVOLVED IN BRINGING THE FIELD UNDER CULTIVATION

"Let us see what are some of the factors involved in bringing the field under cultivation. I know how hard the work is. I have been a field hand for, as McIver once said, 'I've ploughed new ground with a blind mule.'

"In some cases we lay the lack of use of the elements at once to the scarcity of known occurrences. Haber has shown that osmium is the best catalyzer for making ammonia from its elements, but von Welsbach, who devised the osmium-filament lamp, has calculated that there are only a few hundred pounds of osmium available in the periphery of our globe. When, however, we remember that carbon is but 0.21 per cent, while silicon is 25.3 per cent of the crust of our earth for a depth of ten miles including the waters on the earth and its surrounding atmosphere, according to Clarke's calculations, we know that our present utilization of the elements commercially bears but little relation to their total quantity.

"With some striking exceptions, man has found more or less ample sources of the elements or their compounds when it has been shown that our civilization required them. I need but mention tungsten, thorium, vanadium, and radium in illustration. It is not the small percentage in which these elements occur, for palladium exists in nickeliferous pyrrhotites in quantities too small to be detected by even refined chemical analysis, but it accumulates in the slimes of nickel refineries and is thus obtained in some quantity. The price fixed by possession is the deterrent in the development of the use of palladium, a fact of no individual immorality, but contrary to the law of economics.

"Some ten years ago one large corporation possessing a store of palladium was approached by some technologists supported by good repute, with the idea of working out uses for that by-product. The owners said they were not interested in spending a thousand dollars on the investigation—they did not mind spending the money, but they would not be a party to lowering the price of the material in their possession, the inevitable result of extending its use. This principle is well illustrated in the history of metallic aluminium and thorium oxide whose market quotations have fallen to one-hundredth and two one-hundredths, respectively, what they were one generation ago.

"On account of its great resistance to atmospheric oxidation and moisture and to the effect of sulphuretted gases, palladium has been employed for the inner mechanism of chronometers and watches, for the construction of fine balance beams, for the divided scales of delicate apparatus, for surgical instruments. It has been used for coating silver goods, and for electroplating searchlight mirrors, for soldering platinum, and in dental preparations. Palladinized asbestos, palladium sponge and palladium black are most efficient catalytic substances for reducing purposes. This well-known fact may be flashed from the housetops without any fear of coagulating the clouds of litigation hovering over the oil-hardened situation in this country, as the parties referred to still own the palladium.

"Some of these 'unused' elements will be used if the prices are made more reasonable. A very important factor in reducing the market prices of these substances is an improvement in methods of extraction. This I may illustrate from the group of rare earths, not that I mean to lead you into that maze, but because it shows how modern tools have served the purpose and gives suggestions for needed extension with other elements among the 'meta-elements,' as Crookes termed them.

"Monazite sand is essentially a phosphate of the rare-earths containing valuable amounts of thorium, usually 4 to 6 per cent. The problem of obtaining thorium compounds from that source—315,000,000 Welsbach mantles was the world's output in 1913—depends upon (1) solution, usually by baking, with concentrated sulphuric acid and leaching. Very fine grinding of the sand was essential. (2) The rare earths and thorium are then thrown out as oxalates to remove the last trace of phosphoric acid. (3) The mixed oxalates were brought into solution with the destruction of the oxalic acid and the thorium precipitated or the oxalates were treated with ammonium oxalate whereby the non-hydrated thorium tetra-ammonium oxalate went into solution. This thorium salt was subsequently converted into nitrate. With all the price of thorium salts steadily declined until it seemed to reach a limit.

"Muthmann and Weiss conceived the plan of distilling of the phosphorus and converting the metallic elements present into carbides. The resultant mass is hard and is very expensive to grind in order subsequently to dissolve it. The writer later produced calcium carbide within the mixture of other carbides, using the unground monazite sand. This mass when thrown into water crumbles at once to a powder from which the suspended milk of lime is readily washed. The residual mass goes into solution in commercial hydrochloric acid from which the thorium may be precipitated at once in a form readily soluble in the nitric acid. The cerium may be thrown out of the solution from the thorium precipitate and tons of oxalic acid are now destroyed or locked up in the by-product of rare earths which are accumulating awaiting the development of uses.

"Muthmann and Weiss have applied the Hall process for the isolation of metallic cerium, whose use is now practically limited to pyrophoric alloys.

"Very recently it has been proven to be distinctly profitable according to separate patents of Soddy and Hahn, to separate meso-thorium compounds in the process of extracting and purifying the thoria. Meso-thorium rivals radium in some of its applications in radio-surgery.

"The three instances cited above are given for another reason. The ideas were worked out by three college professors. Laborers must be provided for clearing the field, whether the toil be that of working out new processes to so reduce the cost of a material as to admit of its application to uses already known to exist or devise uses not known for by-products now quoted at fictitious prices, but which do not appear at such supposititious values in the annual financial statement.

"Undoubtedly the best way to work out problems of the utilization of 'undeveloped elements' is to attack them in such well-equipped and splendidly manned research laboratories as are maintained by the General Electric Company, the General Chemical Company, the Eastman Kodak Company, and others, but their upkeep involves large expenditures. Many colleges and university professors would welcome a subsidy work of this character, which should be scientific, dignified and help keep the wolf from the door. I commend for your amusing perusal 'The Confessions of a College Professor's Wife' in a recent number of the *Saturday Evening Post*.

"I do not mean that the college professor is prepared to or should go into the factory, but he can work at an idea, which should later be developed, if it has merit, on a commercial scale by the technical chemist or chemical engineer. Elaboration of this proposition, which is not novel with the speaker, is not necessary here. Suffice it to say that one so selected would bring to the problem a degree of ignorance that might be stimulating and a freedom from tradition which would admit of a display of imagination necessary to utilize material which is commercially abundant and inviting investigation.

"H. B. Baker has said somewhere, 'Nothing can be of more value to science than the exhaustive study of one particular action.' Weiss and Neumann have found that compressed zirconium is a conductor, whereas previous statements have been that it was non-conducting. There is need of reviewing many such statements that are handed down in the literature. Aluminium is sonorous, as according to so many textbooks. I have a sample of very pure aluminium, a part of which was used by Mallet in the determination of its atomic weight, and, as he assured me, it is not sonorous. If aluminium is sonorous it is not pure.

"Stewart in his charming book on 'Recent Advances in Physical and Inorganic Chemistry' in referring to 1887 and the following years of feverish activity in physico-chemical research, led by Arrhenius, Van't Hoff, and the elder Ostwald, says: 'To some extent, this wave appears to have spent its force. At the present day physical chemistry, except in the hands of a few exceptional researchers, has degenerated into a means of attacking the problems of pure chemistry instead of opening up new fields; and consequently there is a certain tendency to decry the subjects as a means to an end, and not a living branch of science. This is perhaps an exaggerated view; but it cannot be denied that physical chemists of the present day are not animated by the high hopes which seemed to have inspired Ostwald and others in the earlier days of the subject.' Bancroft acknowledges that there is some truth in this criticism, but asserts 'The difficulty is that most people are still struggling under the limitations imposed deliberately and consciously by Ostwald. Once these are broken through, nobody will have any cause to complain of the wave having spent its force.'

"Stewart further says: 'It is an extremely fortunate coincidence that as the first movement declined, a second and perhaps more powerful one had succeeded it. This second movement rose with even greater rapidity than pure physical chemistry, and yet at the present day we appear to have touched only the fringe of the subject of radioactivity; so that we may look forward to a long career of fruitful investigation still before us in this department of chemistry.'

"The problems of sub-atomic or electronic universe have presented themselves and at once we begin applying these new ideas to utilitarian purposes. The cryogenic laboratories have accumulated fractions from tons of liquid air. Collie found that neon luminesces under the influence of the Hertzian waves. A tube of neon serves as a detector of the nodes and loops, glowing brilliantly under the influence of the latter, as if it were excited by an induction coil. Tubes of neon prepared by Claude thus excited offer a most pleasing and perhaps later on an economical form of artificial light.

"Quantities of argon are now available from liquefied air. There are indications that, on account of its inertness, we may shortly see tungsten incandescent lamps, as Whitney puts it, with the 'vacuum jam-full of argon' instead of nitrogen. Troost and Ouvrard have stated that they have succeeded in causing argon to combine with magnesium vapor. Neither Rayleigh, Ramsay, nor Moissan were able to secure any evidence of the formation of compounds of argon, however. Many reactions unobserved on the laboratory scale are found to occur when dealing with large quantities of substances, through long periods of time. If this were not true we should have even greater difficulty in accounting for the occurrence of such inert gases as helium in malacome, cleveite and thorianite. It is thus barely possible that in time we shall find compounds of argon produced in the large-scale operations of burning the nitrogen of the air, as carried on so successfully in Norway at present. A use of compounds of argon may then be found.

The development of radioactivity has projected us into an undreamed realm of thought and new interests. The phenomena of radiology are closely allied to those of radioactivity. The use of Roentgen rays in medicine has been attendant with not a few difficulties. Among them the so-called 'hardness' and 'softness' of the rays. The former are the penetrating and affect tissues, sometimes favorably and sometimes unfavorably far below the surface. The 'soft' rays affect the epidermis. In the use of 'hard' X-ray tubes for deep treatment, it is necessary to screen the skin with various thicknesses of aluminium, or lead, etc. For treatment of skin affections only there have been no satisfactory means for screening out the penetrating rays, consequently the problem has been the production of 'soft' rays with a minimum of 'hard' rays.

"X-ray tube glass is usually a potash or soda lime silicate. Lindemann found that by substituting lithium for potassium the rays were 'softer.' He then substituted beryllium for calcium, and finally boron for silicon. Lithium-beryllium-boron glass shows over 30 per cent reduction in the empirical molecular weight. Windows of this glass let into X-ray tubes give the 'soft' rays desired. One of these tubes wherein three 'unused' elements are utilized was exhibited through the courtesy of Waite & Bartlett. It would be interesting to try a potassium-barium-zirconium glass.

"In connection with the above I show you samples of titan-quartz and zircon-quartz glass, for which original properties are claimed. Analyses of such quartz published in the *Chemiker Zeitung* show from 0.05 to 0.15 per cent of zirconium and 0 to 0.11 per cent of titanium oxide, so they are what they are not.

"Application of the newer electronic conceptions of valence especially when associated with residual affnity with the development of methods for changing valence according to our wishes will unquestionably cause many of these unused elements and many of those now most used to assume new properties. I call your attention to one qualitative illustration. Pure lead does not plate on iron. When molten lead is caused to flow to and fro as a conductor of a low-voltage, high-amperage alternating-current for variable periods of time, usually several hours, it then plates iron as may be seen from the sample so plated this week. The lead is pitted and the sample not perfect, but it points a way which may serve as a hint in seeking uses for such elements as cadmium, selenium, and tellurium.

"An indifferent and unsatisfying classification of the 'unused' elements has been attempted. Over one-third are little used. 'Rare' elements have been shown not to be so rare. Furthermore, rarity bears little direct relationship to utility. Desire to eat the cake and keep it at the same time are important factors in making use of some of the elements. Illustrations of the development of methods for reducing the cost of production have been cited. Means for stimulating work in utilizing elements now available have been suggested. These workers at least could correct much of the misin-

formation now transmitted by the normal channels from one generation to another. Directions in which real modern physical chemistry has made it possible to use some of these elements and opened up further possibilities have been mentioned. The limited time and assumed patience of our members have forced a degree of unavoidable superficiality.

"These joint meetings and one leading paper remind me of Jerome Travers and his 'Three Men in a Boat.' I have realized from the beginning that the task set me by your three presiding conspirators was no mean one and might perplex even Montmorency. If the weaving of the potash and pearlmutterings of the 'Unused Elements' into a dramatic curtain raiser has not carried interest and profit, lay it not to a sigh which has not been sensitive to lights and shadows but to a memory unable to recall the visions."

Cobalt and Cobalt Alloys

The first paper dealing with a special undeveloped element, namely, cobalt, was presented by Dr. **Herbert T. Kalmus**, of the School of Mining, Queen's University, Kingston, Ontario, who has devoted several years of work to the study of cobalt and cobalt alloys. In view of the interest of the subject we herewith give Dr. Kalmus' paper in full.

The cobalt-oxide industry is a very old one. It probably started, on what might be considered a commercial scale, at Schneeberg, Germany, in 1520; about this time "blue cobalt," cobalt smalt, from Schneeberg, was being sold at Venice. The smalt contained about 6 per cent of cobalt. The smalt industry had a very interesting history in Saxony and Bohemia during the sixteenth to eighteenth centuries, during which time it grew very rapidly. F. Kapff, Finance Minister of Prussia, made a report of the industry in 1792, in which he estimated that thirty smalt works were at that time putting out 3000 tons of smalt per year.

At the present time these German and Austrian mines are important for bismuth and radio-active materials, the silver and cobalt having become quite insignificant. The historical development of this German silver-cobalt district is interesting because it probably forecasts the history of the present Ontario silver-cobalt camp, in that the production of cobalt continued over a long period after the camp had been depleted of its silver values.

During later years up to 1904-05, New Caledonia, New South Wales, Chili, Spain, Norway and Prussia supplied the world with cobalt. The output of New Caledonia at the time the Ontario deposits were discovered was probably 85-90 per cent of the world's supply. In 1904, Mr. A. Glasser, "Report in 1904, to the Minister of the Colonies, on the Mineral Wealth of New Caledonia," stated that New Caledonia has practically the monopoly for the production of cobalt for the whole world. The ores were not smelted or refined in New Caledonia, but were shipped to Europe to be treated.

The silver-cobalt mines of Ontario began to produce in 1904, and since that time they have wrested the monopoly in the production of cobalt from New Caledonia. The price offered for the CoO content of New Caledonia ores, running 8 per cent in CoO, had fallen from about 85 cents per pound in 1904 to approximately 20 cents per pound in 1908.

In the Ontario silver-cobalt district the more important ores in the veins are, native silver, smaltite ($CoAs_2$), niccolite (NiAs), chloanthite ($NiAs_2$), associated with which are usually found some dyscrasite (Ag_6Sb), argentite (Ag_2S), pyrargyrite (Ag_3SbS_3), Cobalt bloom ($Co_3As_2O_8 + 8\,H_2O$) and nickel bloom ($Ni_3As_2O_8 + 8\,H_2O$).

The metallurgical treatment of these ores is more or less secret, but a brief account of the Canadian practice may be found in the report of Mr. Arthur A. Cole, mining engineer, Temiscaming & Northern Railway Commission, Toronto, 1913.

Until the last year about one-half the ore from the Cobalt camp found its way to United States smelters. The ore is silicious and mixes well with United States basic ores. So far as the writer is aware the cobalt content of the ore shipped to the United States has never been recovered to any extent. The present United States practice leaves it in the form of residues containing Pb, Cu, As, Sb, S, Ni, Fe, Ag, and Au; that is, in rather bad shape to be treated for cobalt.

Up until the last year or so practically the only way which cobalt found its way into the industries was as cobalt oxide, Co_3O_4, for use as blue coloring substance. During the last few years the production of cobalt from the Ontario mines much exceeded the consumption of cobalt as cobalt oxide. The writer reported,[1] January, 1913, that the cobalt oxide industry consumed about one-third of the present output of the camp. During the last year the demand for cobalt oxide has considerably increased so that although the cobalt output of the Ontario mines is still very much in excess of the consumption of the metal cobalt, it is no longer true to the degree stated above. A considerable amount of statistical work would be required to make a satisfactory estimate of the present cobalt output of the Ontario mines, but you may take 1000 tons of cobalt metal per year as a rough working estimate, in order to orient yourselves as to the general magnitude.

In the year 1911 the Mines Branch, Canada Department of Mines, arranged with the School of Mining, Queen's University, Kingston, for researches to be undertaken with the view of extending the commercial usages and economic importance of the metal cobalt. To this end this laboratory has been operating continuously during 1912-13, under the direction of the writer.

Researches have been and are being undertaken under the following subdivisions:

I. Preparation of metallic cobalt by reduction of the oxide.

II. A study of the physical properties of the metal cobalt.

III. Electroplating of cobalt and its alloys.

IV. Cobalt alloys of extreme hardness.

V. Cobalt alloys with non-corrosive properties.

VI. Cobalt steels.

The first of these papers is in press, the second is ready for press and the rest will follow during the coming year. The experimental work on all of them has been so nearly completed that they probably can be finished during the present year.

It is impossible at present to give out the details of these investigations in advance of their publication by the Department of Mines, Ottawa, even were it possible to do so in a brief paper; however, the following general statements may be made as a result of the investigations and experiments:

(1) The preparation of black cobalt oxide, Co_3O_4, from Ontario silver-cobalt ores, has been worked out and is at present extensively practised at the Canadian smelters; therefore, this oxide was taken as the raw material for these investigations.

(2) Metallic cobalt, of a very high degree of purity, may be made from this oxide by reduction with carbon, with carbon monoxide gas, with hydrogen gas, or with aluminium; the former three at such tempera-

[1] Summary Report of the Mines Branch of the Canada Department of Mines for the year 1912, p. 94.

tures as to make it commercially attractive and economical.

(3) Metallic cobalt is not so closely identical with nickel in its properties as has been commonly considered.

(4) Cobalt is considerably harder than nickel, being about 125 on the Brindell scale of hardness, whereas nickel is about 65 on the same scale.

(5) Cobalt up to about 15 per cent, alloyed with steel containing small percentages of chromium and tungsten or molybdenum, yields alloys of extreme hardness, and of very superior cutting qualities when used as high-speed tool steels. Nickel substituted for cobalt in these alloys does not in any case give the same results

(6) The melting point of pure cobalt we find to be 1467 deg. C., to within 5 deg., whereas that of nickel is 1435 deg. C. Therefore, so far as its melting point is concerned cobalt is not very much more difficult than nickel to alloy.

(7) Pure cobalt has a higher tensile and compressive strength than any of the pure metals with which the writer is familiar. The effect of cobalt on the tensile and compressive strength of certain alloys and steels is being studied.

(8) Cobalt is magnetic at all temperatures up to about 1100 deg. C. We have found an alloy of cobalt and iron, approximately Fe_2Co, which has a magnetic permeability in strong magnetic fields about 10 per cent higher than the best Swedish soft iron. This has been independently discovered at this laboratory and by P. Weiss, Zurich, Switzerland.

(9) Cobalt alloys with chromium and the resulting cochrome may be swaged to form wires, which are in some respects superior to nichrome wires as heating elements; they are less readily oxidized at high temperatures, and have a higher melting point. The thermo-electric properties of cochrome are being studied.

(10) Small percentages of cobalt added to pure iron give alloys which are extremely non-corrosive and which will probably find extended use as sheet roofing materials. These are at present being tested on a commercial scale.

(11) Cobalt when electroplated on steel and brass gives a more adhesive plate with a more silvery appearance than nickel. It seems to be less readily corroded than nickel under ordinary atmospheric conditions and upon handling.

(12) Cobalt will probably find extended use in the plating industries for special purposes, even at a much higher price than nickel, in that it may be plated with extreme satisfaction from a more concentrated solution than nickel, and at a much higher current density. Cobalt can be deposited several times as rapidly as nickel.

The details of these observations, with numerical constants and complete data, are being and will be published during the coming year by the Mines Branch, Canada Department of Mines, Ottawa, and this brief preliminary note is given with the permission of the Director of Mines.

* * *

Dr. Chandler, called upon to open the discussion referred to some specimens from the Columbia University Museum, exhibited on the lecture table, and spoke of a cobalt anode which he had used many years ago and which had been made at Wharton's shop.

Dr. Baskerville called attention to some samples from the museum of the College of the City of New York, also exhibited on the lecture table.

In reply to a question Dr. Kalmus said as to a comparison of cobalt and nickel plating that a far purer anode of cobalt than of nicked could be used. This is of importance, as Mr. Addicks explained, because on account of the iron contained in commercial nickel anodes the nickel plating deposit will contain iron and therefore be liable to rusting.

In reply to a question of Dr. Richards, Dr. Kalmus said that alloys of cobalt and nickel had not yet been investigated.

In reply to another question as to further comparative data concerning nichrome and cochrome wire, Dr. Kalmus said that these could not yet be given, because the amount of cochrome wire made so far was very small.

Mr. Addicks called attention to a newly developed cobalt deposit, that of Katanga copper in the Belgian Congo, containing 6 per cent Co and 1 per cent Fe.

Mr. Cowles gave some interesting data on early work on copper-cobalt and zinc-cobalt alloys.

The chairman, Mr. Addicks, then passed over to the subject of boron with the following remarks: "Boron represents another class—unbalanced development. It is a peculiar element standing almost alone on the dividing line between the metals and non-metals. The supply is enormous and there is a large consumption of borax and boric acid. Other boron compounds have very limited application and elemental boron was a chemical curiosity until Dr. Weintraub, of the General Electric Company, discovered a glorified application of the borax assay bead, in that boron will deoxidize copper without leaving a dissolved residue, which depresses the conductivity." He then introduced Dr. E. Weintraub.

Boron

Dr. E. Weintraub, of the General Electric Company, West Lynn, Mass., distinguished three periods in the recent development of boron. The first relates to the isolation of boron, the second to the technical applications of boron, and the third to their commercial utilization. We are now well ahead in the third period.

The main commercial uses of boron are based on its peculiar properties of high specific electric resistance and the negative temperature coefficient. The specific conductivity of boron of 0 deg. C. is about 6×10^{-4} mhos per cm cube. This high-specific resistance of boron is accompanied by a negative temperature coefficient of resistance, which is also unprecedented among elements. The resistance of boron drops very markedly as the temperature is increased, and it does this with exceptional rapidity at ordinary room temperature. At this temperature the conductivity of boron doubles in value for every seventeen degrees centigrade.

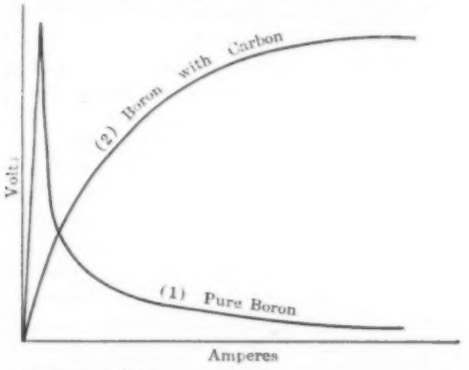
The influence of addition of other elements dissolved in boron is no less interesting. This influence is of extraordinary magnitude so that even as small an amount as 0.1 per cent of carbon, for instance, will increase the conductivity of boron manifold. When 7 to 8 per cent of carbon are dissolved in boron the remarkable characteristics of boron disappear altogether and the material has a conductivity comparable to that of silicon or even carbon.

These peculiarities are best understood by considering the curve connecting the current and the voltage across a piece of boron. In such curves as shown in the diagram on page 186 the amperes are given as abscissas and the volts as ordinates. For a material with a negative temperature coefficient of resistance, such as boron, the curve is necessarily concave to the axis of abscissas.

In the adjoining diagram the curves are plotted not to scale, but simply to bring out the essential difference between pure boron and boron containing carbon. The curve (1) for pure boron shows a clearly developed

maximum. That is, if the current passing through the piece of boron is gradually increased the voltage at the terminals of the piece of boron increases until it reaches a maximum; with further increases of current the voltage decreases. This property at once suggests the use of boron as a cut-out.

Dr. Weintraub expressed the belief that in such cut-outs boron will find a very large field of usefulness especially in connection with series lighting. Whenever the voltage rises beyond a certain value the boron cut-out which before had a very high resistance will break down and open a path for the current.



VOLT-AMPERE CURVES FOR BORON AND BORON-CARBON

If a little carbon is added to boron the nature of the volt-ampere curve changes and by adding more and more carbon the form of the curve (2) in the adjoining diagram may be obtained which reaches a maximum and then remains practically constant, becoming parallel to the ampere axis. Such boron-carbon resistors are practically applicable for voltage regulators. The principle is that if such a boron-carbon resistor is in shunt with a conductor to be regulated, and if the current fluctuates the boron-carbon conductor will absorb more or less current while the conductor in parallel maintains its amperes constant so that the voltage at the terminals remains constant. This property is made use of in car-lighting regulators.

Another type of boron-carbon resistors in an atmosphere of nitrogen (containing a little less carbon than the type just discussed) is employed for automobile lighting regulators to take care of the variations of speed. These regulators are placed in the field of the generator.

Dr. Weintraub finally discussed briefly the possible application of boron resistors as electric thermometers. On account of the great temperature coefficient they should be particularly applicable for such a purpose. The main difficulty has been to make reliable contacts with boron. This difficulty has been bad enough in connection with cut-outs and regulators but has there been completely overcome. On the other hand, this difficulty is much greater with thermometers as in this case the contacts must be absolutely constant. However, Dr. Weintraub concluded that he believed they were now at the end of the difficulties even in this case.

Ductile Tungsten

Dr. **R. W. Moore**, of the General Electric Company, of Schenectady, N. Y., remarked in his paper on ductile tungsten that probably no other element has had such a rapid rise from comparative obscurity to great industrial importance as tungsten since the development of a process of rendering this hitherto extremely brittle metal ductile. Tungsten is by no means a rare element. The two chief minerals are scheelite (tungstate of calcium) and wolframite (tungstate of iron and manganese).

Scheelite is readily broken up with hydrochloric acid, forming calcium chloride, and leaving the tungstic acid mixed with the various insoluble portions of the ore (mostly silica). The tungstic acid may be dissolved in ammonia or caustic alkali and the solution then precipitated with acid to give the crude tungstic acid, WO_3.

Wolframite is most readily broken up by fusion with an alkali flux (caustic soda or carbonate) extracting the alkali tungstate with water and precipitating the tungstic acid as before. This crude oxide, roughly reduced with carbon, is the product used by the steel industry and is the metal that sells for approximately a dollar a pound.

But for the metal that is to be used for making ductile tungsten, this oxide contains too much impurity. The impurities vary with the ore, but the main ones are Fe, Mn, SiO_2, Ca, Mo, P, As, and Na salts. Two methods of purification are in general use:

First, solution in ammonia and crystallization of para ammonium tungstate. This is washed, dried and broken up by heat,

Second, solution in ammonia and precipitation of tungstic acid with hydrochloric acid.

A third method which is used where still greater purity is desired is a combination of the other two, i.e., crystallization and then the decomposition of the crystals with aqua regia.

The first method removes a large portion of all the impurities, but gives a heavy dense oxide from which it is more difficult to get a metal of satisfactory qualities.

The second method gives an oxide purer from some impurities than the crystallation method, but does not remove the P, and As at all completely; these, however, come out later in the process of working the metal. This oxide is light and readily reduced.

Two methods of reduction are being used, one with carbon and the other with hydrogen. By far the greater proportion of the metal used is hydrogen-reduced. Reduction by carbon is much less readily controlled, since under certain conditions the carbon may burn either to CO or CO_2; also some of the lower oxides of tungsten are volatile at fairly low temperatures. The finished metal must contain practically no carbon and practically no oxygen; also the density of the metal must not vary much from a certain standard, and it must not be crystalline. To realize all these conditions is somewhat difficult, but this method is in successful use.

The reduction with hydrogen is more readily controlled and is the process generally used. The oxide is reduced in electric resistance furnaces, with the temperature and rate of hydrogen-flow under careful control. The furnaces used are of two different types: First, porcelain tubes wound with platinum ribbon embedded in an insulating material either alumina or silica, and second, furnaces of the Winne and Dantsizen type, employing alundum tubes wound with tungsten or molybdenum wire, embedded in insulating material, contained in tight casings through which hydrogen is flowing to prevent oxidation of the winding. Each type of furnace has its advantages.

The oxide is loaded into the furnaces, either in boats, or directly into the tubes, purified and dried hydrogen passed through, and the temperature brought gradually up to about 1000° to 1100°. The rate of heating and the rate of hydrogen-flow largely determine the quality of the metal. This reduction process gives a completely reduced metal, without any crystalline structure; the density of the metal is under control and variable at will within the limits.

The tungsten thus produced is a dull-gray amorphous powder. The process of working this powder into a dough, ductile metal is radically different from any in use with other metals (except Mo).

Tungsten melts at about 3200°C. Even in spite of its extremely high melting-point, it is possible to form melted globules of tungsten of considerable size by means of a vacuum arc furnace. But tungsten that has been melted is extremely brittle and a globule of it when struck with a hammer flies into pieces like glass. It is impossible, at least, as yet to work pieces of tungsten which have been melted. Hence other methods of getting the tungsten into wire-form had to be worked out.

In the early days of the tungsten lamp, the tungsten powder was always mixed with some binder, either organic, like starch and the various gums, or metallic, such as some of the amalgams. The mixture was then squirted under pressure through dies, and the binder subsequently removed. Wire made by these methods was extremely brittle and fragile.

Since the process of making *drawn* tungsten wire was developed, practically all wire and other forms of ductile tungsten are made by the following process.

The dry tungsten powder, without binder of any form, is placed in a very heavy mold, care being taken that the powder is evenly distributed in the mold. The metal is then pressed into a bar by heavy pressure in a hydraulic press. This pressed rod has very little strength. It is carefully pushed from the surface of the mold into a slab of some material (usually molybdenum) and then placed in a furnace, usually of the Winne and Dantsizen type, heated to about 1300°. A current of hydrogen is passed through the tube to prevent oxidation. The bar is heated for about half an hour and then pushed out into a water-cooled extension of the furnace. This heating has sintered the metal so that the bar has sufficient strength to be readily handled without fear of breakage.

This bar is now clamped between two heavy water-cooled clamps, and a water-cooled cover or treating-bottle as it is called, is lowered over the whole. A current of dry hydrogen is passed through the bottle, and the bar then heated gradually up to a dazzling white heat—in fact nearly to its melting-point, by passing current through it. After a few minutes at this temperature the current is gradually turned off (to prevent air sucking back into the bottle and causing an explosion) and the bar allowed to cool. The tungsten is now thoroughly sintered and the bar is very strong—but as yet it has no ductility whatever.

From this point on, the treatment of the bars varies slightly, according to the use to which the metal is to be put. Sometimes the metal is rolled—sometimes swaged. The process in general is this: The bar is placed in an electric resistance furnace through which hydrogen is flowing, and heated to about 1500° C. (till it smokes in the air). It is then grasped with tongs and inserted rapidly into a swaging machine and then quickly withdrawn. It is reheated, and the other end passed into the machine. Care must be taken that the rod is passed rapidly into and out of the machine, so that it is not cooled too much.

The size of the dies is gradually decreased—several dies are used in bringing the rod from a square to a circular form. As the rod becomes smaller, the steps between the dies gradually become smaller and smaller, the temperature is gradually decreased, and when the rod is long enough it is fed through the machine mechanically by rolls, being drawn through a gas furnace or gas flame to heat it. When the diameter has been reduced to about 30 mils, the wire becomes ductile at ordinary temperature.

From this size, down to the smallest diameter the wire is drawn through diamond dies, first quite hot (600° to 650°) with a gradually decreasing temperature as the wire becomes smaller. The steps between the dies are gradually decreased from one mil at thirty mils to one-twentieth of a mil at fourteen mils and below. Wire as fine as one-half mil has been successfully drawn.

When not desired in the form of a wire, the treated bars are often rolled instead of swaged; sometimes both processes are combined. The metal is rolled hot in a manner similar to that used in swaging. From the rolled bars and sheets, various articles are made, such as contacts for electric apparatus of various kinds, X-ray targets, etc.

Tungsten is too hard to work on a lathe, or to be machined with tools. Hence other methods have to be used to get tungsten into any desired form. The metal sheets or bars are heated very hot, and then the desired pieces sheared, punched or forged out.

The properties of wrought or ductile tungsten are interesting. It is pliable, strong and tough. It is practically non-oxidized in damp air, and it resists acids to an unusual degree. It is unattacked by HF, only slightly attacked by HCl, HNO_3 or H_2SO_4 of any concentration hot or cold, or by aqua regia. Alkali solutions do not attack the metal, but fused alkalis dissolve it slowly. A mixture of HNO_3 and HF dissolve the metal rapidly. The specific gravity of tungsten is about 19.3. Its tensile strength is exceedingly high-samples of one-thousandth of an inch diameter have been obtained with a tensile strength of 600,000 to 650,000 lb. per sq. in. (several times that of steel).

The most important use for tungsten is, of course, as a filament for incandescent lamps. It is also being extensively used as a contact material where an electric circuit has to be made and broken repeatedly in the air, as in magnetos, etc., on automobiles, and in voltage regulators. Considerable use is being made of tungsten as a target in X-ray tubes, where it is being found exceedingly valuable. Tubes of tungsten are made and used as the heating unit in a furnace, in which a temperature of 2500°-2700° can be obtained in about five minutes, starting at room temperature. The furnace can be cooled and opened in about ten minutes, hence such a furnace is of the highest value in experimental work at high temperatures. The furnace can be filled with hydrogen or used as a vacuum furnace as desired.

A further use of tungsten is as a heater-winding for resistance furnaces such as the Winne and Dantsizen type and others. The temperature at which these furnaces can be run is limited at present only by the temperature which the tube or support on which it is wound will stand.

Selenium, Tellurium, Cadmium

The chairman, Mr. Addicks, remarked that "selenium, tellurium and cadmium are three sad cases. The supply is fair and the consumption very small. Of course, they are used in medicine to a certain extent, but a doctor will use anything. The prescription of one of the fifteenth century physicians for the cure of fever began, after discussing the position of the stars: One heats in a brass pan 1½ oz. turpentine of cyprus and then introduce fifteen live spiders and mixes until the spiders have disappeared.

"Selenium has the property of imparting to the perspiration its characteristic odor, which is stated in the chemistries to resemble rotten radishes. It has been said that physicians find it an excellent ingredient for prescriptions where the patient is suffering from overwork and insists on going out to dances. . . ."

There was an interesting exhibit of several products of colored glass of the Corning Glass Works, of Corning, N. Y. In some interesting notes contributed by Mr. E. C. Sullivan it was stated that selenium produces a ruby glass much more satisfactory in transmission than any other ruby and they are using several thousand pounds yearly in the manufacture of such glass. Selenium, is recommended also for use as a decolorizer as it gives in small quantity a pink color which is complementary to the green color caused by iron.

With regard to cadmium sulphide they are using a few tons of this material annually to produce yellow color.

This company makes lantern globes and roundels for railway signal purposes, the red being obtained with selenium and the yellow with cadmium sulphide. Mr. Sullivan remarked that they were always interested in the less common elements since a decrease in price might make available for their use materials which are otherwise out of the question. Lithia and bismuth are possibilities along this line which suggest themselves at the moment.

In view of the late hour there was a comparatively brief discussion. Mr. J. B. F. Herreshoff spoke of the behaviour of selenium in the smelting and refining of copper and emphasized the influence of small quantities of foreign elements in copper on its electric conductivity.

After the close of the meeting the numerous exhibits on the lecture table were inspected with great interest by the audience. Besides the exhibits from the museums of the College of the City of New York and of Columbia University and of the Corning Glass Works there was also an interesting exhibit by Messrs. Eimer and Amend in charge of Mr. Childs. The whole evening was very enjoyable.

An Apparatus for Making the Flash and Fire Tests of Lubricating Oils

BY H. L. SIEVER

By flash test we understand that temperature to which an oil must be heated to give off vapors, which when mixed with air produce an explosive mixture, while the fire test of an oil is the temperature at which it will give off vapors, which when ignited will burn continuously.

The latter temperature being obtained by continuing to heat the oil after the flash test is made.

Oils with a high flash point, such as lubricating oils, are as a rule made in an open cup or crucible, heated by a Terrill burner in an air or a sand bath.

The results obtained by making these tests in an open crucible are not always satisfactory.

There are several things to be considered when using a crucible, such as the quantity of oil, size of crucible, rate of heating, distance, and size of flame, draughts, etc., in fact unless these tests are made quite frequently one often forgets the exact conditions under which the previous tests were made. Porcelain crucibles are usually used for this purpose, but at high temperatures they often break, causing trouble, delay and expense. The accompanying illustration gives the dimensions for making a tester of machine steel which has proved to be very reliable and convenient in determining these temperatures.

It can be made of any cheap iron or steel at a small cost, and will last almost indefinitely.

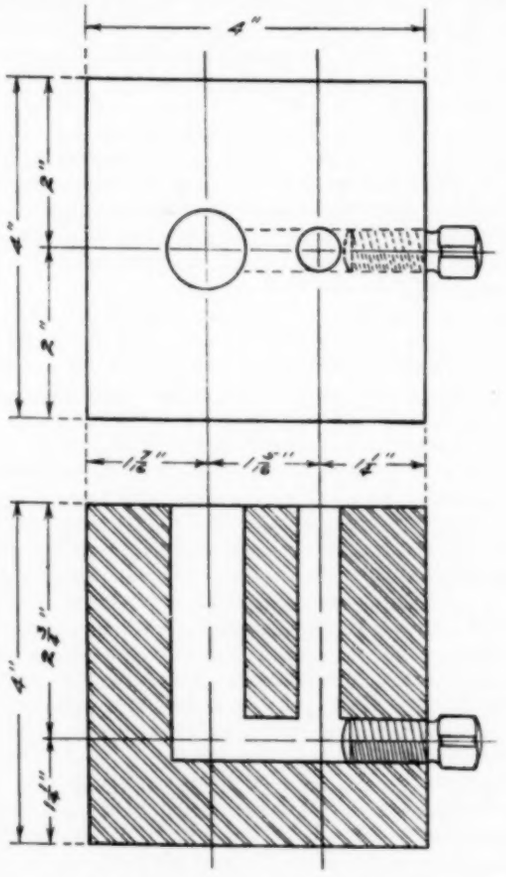
The advantages of this over an open crucible and sand bath are obvious. The most important being the volume of oil, which is the same for all tests, while the thermometer is entirely removed from the larger portion of oil where the test is to be made.

In practice this is placed on an ordinary iron support with a clamp for holding a thermometer.

Pour 35 c.c. of the oil to be tested in the large ⅞-inch hole and insert the thermometer in the small ½-inch hole, apply a fairly hot flame from a Terrill burner as near the center as possible.

The testing flame should be very small and applied at the edge or drawn across the top.

With this apparatus it is possible to accurately determine these temperatures to within one-half a degree.



SKETCH OF TEST ARRANGEMENT

By removing a set-screw with a pair of pliers the hot oil may be drawn off and arrangements made for a new test in a few minutes.

Laboratory, Morse Twist Drill & Machine Co.,
New Bedford, Mass.

Preliminary statistics of the value of metal production in the western states for 1913 have been given out by the Geological Survey: Alaska, $18,900,000, a decrease from 1912 of about $4,000,000; Arizona, $71,000,000 which is record output and an increase of 6 per cent; Colorado, $36,000,000 gold and zinc having decreased and silver, copper and lead increased; Idaho, $23,500,000, which is a record for that state and an increase of nearly 10 per cent; Montana, $59,000,000, a decrease of about half a million dollars, gold and copper having decreased while zinc made a record yield; Nevada, $36,374,000, a decrease of about 5 per cent, gold and lead having fallen off while silver, copper and zinc gained; New Mexico $11,600,000, an increase of $3,000,000, due mostly to copper; South Dakota, $7,200,000; Utah, $43,000,000, a slight increase. The production of coal, iron ore and petroleum broke all records, amounting respectively to 575,000,000 short tons, 58,000,000 long tons and 240,000,000 barrels.

Mining Engineers' New York Convention

Report of the Annual Meeting of the American Institute of Mining Engineers, Held in February in New York City

The annual meeting of the American Institute of Mining Engineers held in New York City from February 16 to 19 was a most enjoyable affair and was very well attended.

On Monday night there was a reception at the Institute's headquarters, opened by an address of welcome by President Charles F. Rand, and followed by a "mining-colored" smoker in which the humorous home talent of the Institute shone brilliantly.

The annual business meeting was held on Tuesday morning, when the results of the election of officers were announced. The number of ballots cast was 949.

Mr. Benjamin B. Thayer, president of the Anaconda Copper Mining Co., is the new president.

Messrs. H. C. Hoover and W. L. Saunders were elected vice-presidents and directors, and Messrs. R. W. Brock, D. C. Jackling, A. L. Ledoux, C. W. Merrill and Henry Smith, directors.

On Tuesday evening a meeting was held in the Museum of Natural History, at which the chairman of the New York section, Mr. L. B. Huntoon, presided. Mr. H. W. DuBois presented a beautifully illustrated lecture on "Placer Mining in British Columbia." The new model of the Copper Queen Mine, prepared with extreme accuracy and a gift of Dr. James Douglas to the Museum, was on exhibition. Dr. E. O. Hovey outlined the history and geology of the district, and Prof. James F. Kemp gave an appreciative sketch of the life and work of Dr. Douglas.

On Wednesday evening a subscription dinner at the Waldorf-Astoria was attended by some 200 members with their ladies. Mr. W. L. Saunders acted as toastmaster. Among the speeches, one by Senator Clark was particularly enjoyed. The banquet was preceded by a reception to the newly elected president, Mr. Thayer and the retiring president, Mr. Rand, and at the close of the dinner Mr. Rand introduced Mr. Thayer as the new president.

The professional sessions devoted to the reading and discussion of papers were well attended and extraordinarily successful. The scheme to give the different sections of the Institute a free hand in preparing the program and procuring papers proves very effective. During the last two days the program was so crowded that it was necessary to hold simultaneous sessions in two different rooms.

Tuesday Morning Session

During the Tuesday morning session, which followed the annual business meeting, Mr. Spilsbury presided.

A paper by **H. A. Guess** on "Mining and Mining Methods in the Southeastern Missouri Disseminated Lead District," and a paper by **James Johnston** on "The Mill and Metallurgical Practice of the Nipissing Mining Co., Ltd., at Cobalt, Ontario," were presented in abstract by Mr. Robinson, in the absence of the authors. In view of the great metallurgical interest of the latter paper, we herewith give an abstract of the same:

Nipissing Mill and Metallurgical Practice

At this mill a remarkably complex silver ore, averaging 54 oz. of silver per ton (run of mine ore) is treated to give a 95.66 per cent. extraction. Mr. Johnston points out that the main features of the processes are:

The cyanide amalgamation of the high-grade ore.

The cyanide treatment of the low-grade ore, after extremely fine grinding and close classification, in a caustic soda solution.

The use of a wet desulphurizing process to break up refractory silver minerals.

The substitution of aluminium dust for zinc dust as a precipitant.

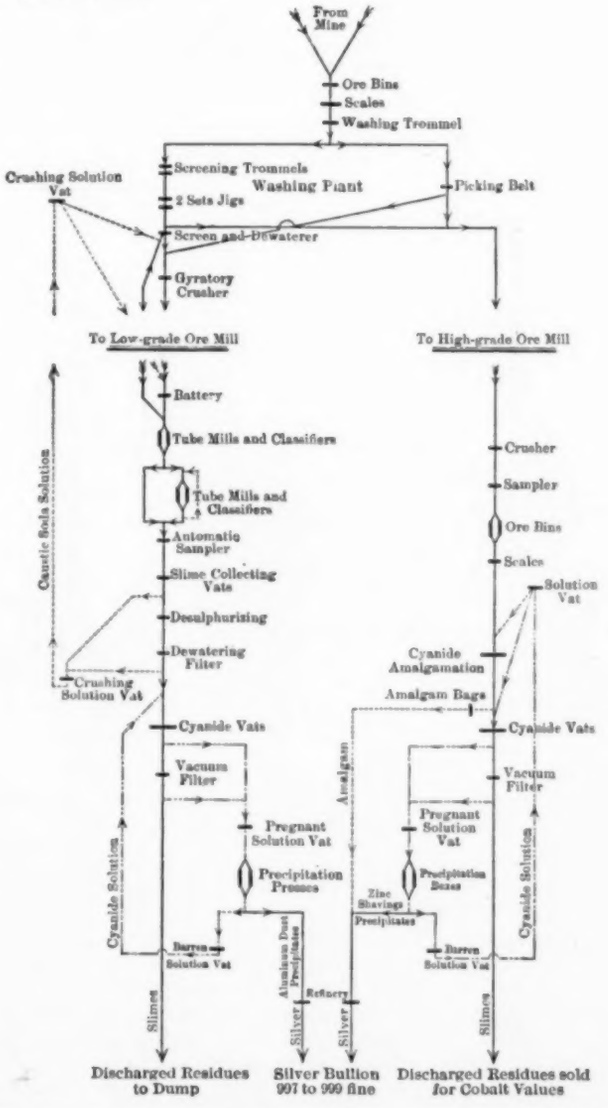


FIG. 1—FLOW SHEET OF NIPISSING MINING COMPANY'S MILL

The recovery and shipment of over 13,000,000 oz. of silver in bullion at 997 to 999 fine since this metallurgy was inaugurated, about 2.5 years ago.

After a review of the experimental work which preceded the design of the mill by Mr. Charles Butters and the author, the present mill practice is summed up as follows:

Crushing the ore to 3 in. in gyratory crushers before sending it to washing plant.

Hand picking and jigging of the high-grade ore in the washing plant, which is then sent to the high-grade ore mill.

Discards from washing plant, known as low-grade ore, crushed to 1.5-in. mesh and sent to battery.

Crushing in battery and tube mills in a caustic soda solution to all slimes.

Collecting slimes and desulphurizing in tube mill and vat.

Dewatering slimes and transferring to vats for cyanide treatment.

Filtering slimes and discharging to waste dump.

Cyanide solution from slime treatment vats and filters going to aluminium dust precipitation.

Aluminium dust precipitate taken to refinery, malted, and refined to silver bullion at 997 and 999 fine.

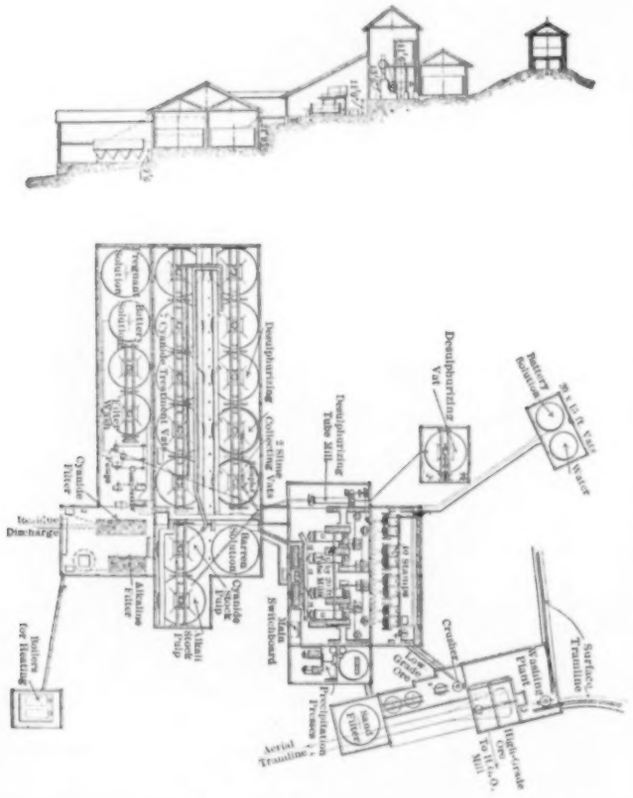


FIG. 2—PLAN AND SECTION OF THE LOW-GRADE ORE MILL OF THE NIPISSING MINING COMPANY

The flow sheet of the process is shown in Fig. 1, and the low-grade ore mill is shown in plan and section in Fig. 2.

Descriptions, with data on cost of erection, are given in the paper, of the foundations, the mill building, the washing plant, the battery, the tube mills, tonnage and values, launders, and the cyanide plant. The latter is placed in a building apart, but connected to the battery and tube mill building. It is arranged in two floors, the upper one containing all the slime collecting and the cyanide treatment vats and the lower floor containing all the solution vats, slime filters and pumps.

The desulphurizing process is an important novel feature of the process, so we give that portion of the paper which deals with it practically in full.

DESULPHURIZING PROCESS

The problem of working out a successful all-cyanide treatment for Cobalt ores, in which there is such a varying amount of complex minerals, led to the discovery, during the period of experimental work, of what is now known as a wet desulphurizing process. Briefly explained, the preliminary desulphurizing treatment breaks up the refractory silver minerals when the slime pulp is brought into contact with aluminium in a caustic soda solution, the silver being left in a spongy metallic state readily amenable to cyanide treatment.

The desulphurizing is accomplished by passing the slime pulp through a revolving tube mill, in which there is a quantity of aluminium, and a further treatment is given in a vat lined with aluminium plates, in which the pulp is slowly agitated.

The practical effects of this preliminary treatment on the ores has resulted in the same and sometimes a better extraction being obtained in 48-hr. cyanide treatment than was otherwise obtained in 120-hr. cyanide treatment with no desulphurizing. In some of the ores which contained a greater proportion of the refractory minerals a better extraction of from 1 to 4 oz. per ton is obtained when desulphurized and cyanided, as compared with a cyanide treatment and no desulphurizing.

A tube mill, 4 ft. in diameter by 25 ft. long, lined with 2-in. thick Silex blocks, is used for the first stage of the desulphurizing treatment. This mill revolves at 10 revolutions per minute and carries a load of about 4000 lb. of aluminium ingots, cut up into cubes about 1.5 to 2 in. The slime pulp is fed through this mill at the rate of 14 tons of dry slimes per hour, diluted with 1.5 caustic soda solution to 1 dry slime. The pulp then gravitates into the 34-ft. diameter by 13-ft. deep alkali stock pulp vat, which is arranged with mechanical agitation and lined around the side with aluminium plates. The pulp is agitated in this vat about 24 to 36 hr., or until it is gradually drawn off in about 40-ton charges to the dewatering filter box. On account of keeping the mill cyanide solution in balance, it is necessary to eliminate as much as possible the crushing caustic soda solution from the slimes before they are transferred into the cyanide vats for treatment, and this is done in a Butters filter plant equipped with 60 leaves, which is capable of dewatering 270 tons of slimes per day, the cake when discharged carrying 26 per cent. alkali solution as moisture.

The slimes after dewatering flow into a 16 ft. by 5 ft. deep pulping vat, where they first come in contact with cyanide solution, being diluted with about 2 of cyanide solution to 1 of slime, a 4 in. diameter centrifugal pump being used for transferring the pulp into the cyanide treatment vats.

CYANIDE DEPARTMENT

There are seven 34-ft. diameter by 13 ft. deep slime treatment vats, fitted with mechanical stirring arrangement. Each vat has a 6-in. diameter decanter, for draining off the clear settled cyanide solution they are also fitted with a 6-in. diameter air lift operated by 0.75-in. diameter pipe with air at 20 lb. pressure.

The slimes are treated in charges of about 130 tons dry slimes in a vat with a dilution of 2 of solution to 1 of dry slimes in a 0.25 per cent cyanide solution and 0.20 per cent alkali, agitation being maintained for 48 to 60 hr. Repeated testing in the mill has demonstrated that equally as good an extraction of the silver values is obtained with a 2 to 1 dilution as with a 3 to 1 dilution. The air lift is operated all the time the charge is being treated, so that there is a possible turning over of the charge about 16 times by the air lift.

After the agitation treatment, the charge is allowed to settle, so that the clear solution may be decanted to the pregnant solution vat. The pulp is then agi-

tated and transferred by a 7-in. diameter centrifugal pump to the 34-ft. diameter by 13-ft. deep cyanide stock pulp vat, in which it is kept agitated until drawn off into the filter box.

A Butters filter plant equipped with 80 leaves handles 35 to 40-ton charges in about 3 hr. each, the slimes being discharged with 26 per cent of moisture. The alkali and the cyanide filters are arranged alongside of each other so that the same operator handles both boxes from the switchboard placed between them. The filter plants are arranged on the semi-gravity plan; a 10-in. diameter centrifugal pump with 12-in. diameter suction and delivery pipes and hydraulically operated valves is connected with the cyanide box for transferring the excess pulp and solution wash. The clear solution from the cyanide filter box is delivered to the pregnant solution vat and the residue slime is dropped into the empty box, discharging by gravity to the residue dump.

The alkali filter box is connected to an 8 by 10-in. duplex double-acting piston vacuum pump with a displacement of 340 ft. per minute at 160 revolutions per minute. The cyanide box has a 12-in. diameter by 10-in. stroke duplex double-acting piston vacuum pump with a displacement of 770 ft. per minute at 160 rev. per minute.

The pregnant solution vat is 34 ft. diameter by 8 ft. deep and the barren solution vat is 34 ft. diameter by 13 ft. deep.

PRECIPITATION DEPARTMENT

The original plans of this section of the mill were laid out with the intention of using zinc dust for precipitation and an equipment was installed of one 20-frame and one 10-frame 52-in. Merrill precipitation presses with 3-in. frames, together with the other necessary machinery.

Before the mill was ready to start, the experimental work on the use of zinc dust as a precipitant had disclosed that the cyanide solutions after precipitation rapidly deteriorated and fouled, so as to lose their dissolving efficiency. After considering various other methods of precipitation, it was decided to use aluminium dust as the precipitant and modify the equipment accordingly.

The practical benefits gained by this change are:

No fouling of cyanide solutions, with a corresponding reduction in dissolving efficiency.

The working mill cyanide solutions are in a more active condition to dissolve silver than if they were freshly made up solutions which had not yet been used, showing in their favor an increased dissolving power of 0.35 oz. of silver per ton of ore.

A regeneration of 0.608 lb. of cyanide per ton of solution precipitated, equal to about 1.67 lb. of cyanide per ton of ore treated, or 408 lb. per day.

The recovery of silver precipitates averaging about 27,000 oz. per ton, or about 93 per cent silver.

The pregnant solution is pumped to the precipitation room by a 6 by 9-in. vertical triplex pump, running at 54 strokes per minute, where it is clarified in a sand filter before flowing to the special tank arrangement for mixing the aluminium dust in the cyanide solution. It is then pumped into the precipitation presses by another 6 by 9-in. vertical triplex pump. The 20-frame press takes about four days to fill up with precipitates when handling about 550 to 600 tons of solution per day with a head assay running about 8.25 oz. and a tail assay 0.10 oz. The aluminium dust consumption over a nine months' period averages about 0.556 lb. per ton of ore treated, or 1 lb. (avoir.) dust = 45.26 oz. (troy) silver precipitated, or 1 lb. (avoir.) dust = 3.104 lb. (avoir.) silver precipitated. The precipitates are sent to the refinery, where they are melted and refined in a reverberatory furnace, as described in R. B. Watson's article, and eventually shipped as bullion at 997 to 999 fine.

A heating plant is provided which maintains an average temperature of about 60 deg. F. in the coldest weather, which is sometimes down to 40 deg. below.

The paper (which is published in full in the January issue of the *Bulletin* of the Institute) is concluded by figures of extraction, operating costs, and electric power.

In the discussion which followed, Mr. T. T. Read, emphasized how much valuable research work is now being carried out in this country. Mr. Spilsbury called attention to the high extraction obtained in comparison with the Mexican practice. Mr. Packard spoke on early pioneer work in Utah and Montana in the cyaniding of silver ores. Mr. Chauvenet attributed the recent big advances in cyaniding to two causes, namely, fine grading and the slime filter. Mr. Hore sketched the advances made at Cobalt in low-grade ore treatment.

Tuesday Afternoon Session

During the afternoon session, at which Mr. Wm. Kelly presided, the chief subject of discussion was the use of electricity in mines. The program of the afternoon session was as follows:

Use of Electricity at the Penn and Republic Iron Mines, Michigan, by Wm. Kelly and F. H. Armstrong.

The Application of Electric Motors to Shovels, by H. W. Rogers.

Remarks on Electric Traction in Mines, by Charles Le Grand.

Safeguarding the Use of Electricity in Mines, by H. H. Clark.

The Safety of Underground Electrical Installations, by C. M. Means.

The Injection of Cement Grout into Water-Bearing Fissures, by Francis Donaldson.

Drilling Performances at the Kensico Dam, Catskill Aqueduct System, New York, by W. L. Saunders.

The Work of Crushing, by Arthur F. Taggart.

Wednesday's Sessions on Iron and Steel

Papers on iron and steel were presented in the two sessions on Wednesday. Dr. **A. Sauveur** presided at the morning session, and Dr. **J. W. Richards** at the afternoon session.

The first paper, by **H. M. Howe** and **A. J. Levy**, on the plastic deformation of steel during overstrain, was presented by Professor Howe. The subject was discussed on the basis of a fine series of microphotographs, shown by lantern slides. The paper was discussed by Professor Carpenter, of London, and Messrs. Hibbard, Webster, Sweetser, Lindgren and Howe. There was an enjoyable exchange of international pleasantries between Professor Carpenter on one hand and Dr. Sauveur and Professor Howe on the other.

A paper by **Albert Sauveur** on some heating and cooling curves of Carpenter's electrolytic iron followed. Dr. Sauveur concluded that the existence of A2 in pure iron as an independent point is no longer a debatable question. Whether this point is or is not an allotropic point appears to depend upon our conception of allotropy. The paper was briefly discussed by Professors Carpenter and Howe.

Two papers presented during the morning session dealt with manganese steel. A paper by **B. Hopkinson** and Sir **Robert Hadfield** on a research with regard to the non-magnetic and magnetic conditions of man-

ganese steel was presented in abstract by Dr. Richards and discussed by Messrs. Potter, Howe and Sauveur.

A paper by **W. S. Potter** on manganese steel with special reference to the relation of physical properties to microstructure and critical ranges was presented by Mr. Potter. He showed a very long series of lantern slides and was complimented by Dr. Sauveur on the vast amount of information contained in the paper.

Oxygen in Cast Iron

The paper by **Mr. J. E. Johnson, Jr.**, on the influence on quality of cast iron exerted by oxygen, nitrogen and some other elements, proved the most sensational and most debated paper perhaps of the whole meeting. The paper is printed in full in the January issue of the *Bulletin* of the Institute. We give here only an abstract of the paper with such information as was given by Mr. Johnson at the meeting on more recent developments.

Mr. Johnson's argument is as follows: Ordinary chemical control does not determine completely the quality of iron. Certain irons of apparently the same chemical composition, as determined by ordinary analysis, have different qualities, structure, strength, etc. These qualities are preserved on remelting and reappear in castings of which these irons form an important ingredient. The explanation cannot be found in the rarer elements, such as nickel, cobalt, chromium, titanium, vanadium and the like. All this is proven by a great deal of experimental evidence.

As it seemed inconceivable that a quality which would survive remelting and superheating to a point well above the fusion point, as in foundry practice, should be a purely physical quality, the explanation was sought in the common gaseous elements, oxygen, nitrogen and hydrogen. Mr. Johnson claims to have found the explanation in the oxygen content.

Mr. Johnson discusses the content of oxygen in coke irons and in charcoal irons and gives the results of tests proving the following two facts:

First, strong, tough irons of high chilling qualities contain oxygen in appreciable quantities. Weaker irons of similar analysis contain less or no oxygen.

Second, poor and normal irons may be improved beyond recognition by introducing oxygen into them.

As to the conditions in which the oxygen exists nothing is known. "We have been unable to detect it with the microscope, and we can only assume that it is some oxide of very much lower degree than any with which we are familiar."

Its effects seem to be two-fold:

First, it makes the iron very much more sensitive to chilling influences. One of these good irons if cooled normally will be only slightly harder than a normal iron, and on account of its fine, close grain will machine beautifully, but if the surface be chilled even slightly it begins to whiten up, and with a chill of any strength will be solid white at the edge, where a normal iron of the same silicon would show little chill, or none at all.

Second, the other principal effect consists in the extremely fine subdivision of the graphite in the strong irons, contrasting conspicuously with the large, coarse aggregates of graphite in the weak irons.

This was clearly shown by Mr. Johnson at the meeting in a series of microphotographs. These were shown in pairs. The two irons of the same pair had the same chemical composition, with exception of the oxygen. The two structures shown side by side showed clearly the large, coarse, aggregates of graphite in the low-oxygen iron (weak iron) and the finely subdivided graphite in the high-oxygen iron (strong iron).

A further condition which exists in these high-oxygen irons is that the tendency to form plates of eutectic and to form a spot in the center of the pig is entirely suppressed, no matter what the silicon of the iron may be, even with quite high carbons.

The subject is further discussed by Mr. Johnson under the following headings: Comparison of high-oxygen cast iron and malleable cast iron; reason for low-oxygen content ordinarily; condition for high-oxygen content; coke-furnace conditions as regards oxygen, the effect of different types of heat balance on quality of iron high versus low carbon; the effect of other elements (nitrogen, cyanogen, phosphorus, chromium, manganese), and the reason for the poor quality of manganese and chrome chills.

Mr. Johnson's final conclusions are summed up as follows:

"1. Irons which contain oxygen to a considerable extent, in a form as yet unknown, are stronger and tougher and have better chilling qualities than irons containing less of this element, but of the same analysis in other respects.

"2. Irons may contain a sufficient quantity of carbon to make them rotten and worthless through the predominance of the eutectic structure when deficient in oxygen, and yet, when they contain a considerable quantity of oxygen, be entirely free from this structure and of excellent quality.

"3. Furnace conditions control whether the carbon shall be below or above the eutectic ratio and the presence of much or little oxygen, the two dominant factors in the fundamental quality of the iron; that iron, broadly, being the best which is made at the lowest temperature.

"4. Charcoal irons can be made at temperatures several hundred degrees lower than are practicable with coke and have a great possible advantage in that respect. This is largely wasted without good furnace work in the broadest sense.

"5. Phosphorus up to 0.50 per cent or more exercises a beneficial influence on the strength of the iron and the depth and character of the chill. Phosphorus also has a tendency to reduce total carbon.

"6. Aluminium and titanium tend to reduce the strength and chilling power of the iron by removing its oxygen, but titanium may have an influence independent of this on account of its removing nitrogen also.

"7. Chromium and manganese have an almost identical effect in raising the total carbon and throwing it into the combined condition. The latter increases the chill and the strength, but the combined carbon so produced is in the form of eutectic plates, which deprive the iron of much of the strength which it would have with the same combined carbon in the absence of these plates.

"8. Chill produced by these elements cannot be expected to have the same wearing qualities as that produced by elements which do not further the formation of flat plates of eutectic."

The paper elicited a long and lively discussion.

Dr. Moldenke said that while he agreed with much that is in Mr. Johnson's paper, yet he could not accept his main conclusion that oxygen is beneficial.

Professor Howe pointed out that according to Mr. Johnson, not the oxygen itself but the resulting reduction of the graphite from large flakes to smaller particles is the really beneficial element.

Mr. Stoughton defended Mr. Johnson against the attacks of Dr. Moldenke. It is simply claimed that

the irons with more oxygen content have a better structure. The oxygen may have an influence in throwing the eutectic point to the right, though there is no direct evidence for this statement.

Professor Campbell suggested a way how the oxygen may affect the method of throwing out the graphite—which is so important for the final structure.

After Messrs. Hibbard, Stoughton and Sweetser had discussed the existence or non-existence of such a thing as good iron that makes bad steel, and Mr. John Howe had called attention to some new test results not yet given in Mr. Johnson's printed paper, but confirming his claims, Dr. Moldenke reiterated his conviction that oxygen in cast iron cannot be beneficial. This, he said, was not theory, but the result of his foundry practice of many years.

In his final reply Mr. Johnson referred to some experiments made recently by him with the object of converting ordinary coke iron into iron of a grade equal or superior to charcoal iron. These experiments have been exceedingly successful. He took an ordinary iron of about 1 per cent silicon and cast 1¼-in. round test bars from it. He then treated this iron so as to introduce oxygen into it, and from this same heat cast additional 1¼-in. round test bars; after treatment the iron contained about 1 per cent of silicon as before. The first set of bars broke very uniformly at from 2000 to 2500 pounds, about the normal for coke iron. The set of bars made after treatment also broke very uniformly, but at from 3800 to 4200 pounds. This iron had the chilling power and closeness of grain of the best grades of charcoal iron. Some 2-in. square test bars were also made from the treated metal and these broke from 19,000 to 24,000 pounds on 12-in. centers. considerably higher than the most rigid specifications for the best grades of charcoal iron. The cost of this treatment is low. It is estimated that the conversion cost will range from $2.00 to $5.00 per ton, according to the daily tonnage converted.

Heat Treatment of Steel Castings

A paper by Messrs. **C. D. Young, O. D. A. Pease** and **C. H. Strand,** of Altoona, Pa., was presented by Mr. Pease.

In an effort to employ cast steel of a stronger structure than that found is the annealed steel castings, the possibilities of heat treatment which will increase the strength without materially decreasing the ductility may be resorted to.

The paper gives a brief outline of what has already been done by the Pennsylvania Railroad Co. at its shops and test laboratories at Altoona, Pa., and is of material interest, as it indicates what may be done with steel castings when properly treated, thereby permitting in railway service greater strength of cast steel parts without any increase in weight or space.

The obscurity formerly surrounding the heat treatment of steel has been for the most part removed by the development of our knowledge of the critical points of steel, pyrometers, furnace construction, and the testing of the finished product.

The operations of the heat treatment proper are taken up under the heads of (1) heating for quenching; (2) quenching; (3) drawing.

(1) *Heating for Quenching.*—Heating for quenching is best conducted slowly, especially in the case of castings of variable thickness. Cracks may occur either in heating or in cooling, due to different temperatures at different points of the casting. The castings should be thoroughly soaked at the maximum temperature (generally 1500 deg. to 1600 deg. F.), 1 hr. being sufficient for sections 1 ft. in thickness. The minimum temperature which will produce the desired hardening effect will, in all cases, be found to be the most satisfactory, as the grain coarsens when the critical range is exceeded to too great an extent. All temperatures should be governed by a checked pyrometer with the hot junction to the heated object, and with several couples in a large furnace to insure a uniform temperature.

(2) *The Quenching Operation.*—The casting should be transferred as quickly as possible from the furnace to the quenching bath, and in the case of large castings, such as locomotive frames, this is by no means a simple matter. The largest castings are best handled by means of cranes and rollers.

The quenching agent employed is generally water or oil, preferably the former, because of its cheapness and drastic cooling effect, more readily breaking up the coarse cast-steel grain. With intricate castings it is generally best to use oil. With water, it is possible to have a large tank and a large running stream, serving to maintain a uniform temperature. Castings should never be thrown in to rest on the bottom of the tank, but should be agitated to prevent the formation of a coating of vapor, retarding the quenching effect. It is also best, whenever possible, to quench the thicker portions first.

(3) *The Drawing Operation.*—Whenever possible, the drawing should be done in a bath of some kind, such as lead, barium chloride, a barium chloride-salt mixture, or oil. In the case of large castings this is manifestly impossible, and great care should be exercised in obtaining a uniform temperature in the drawing furnace.

The use to which the casting is to be put determines the drawing temperature, railroad work, by reason of the shock and vibration of the road, requiring high ductility at the sacrifice of some strength.

A table is given showing the results of some tensile, chemical and micrographic tests of commercially annealed and experimentally heat-treated cast steel bolsters. The paper also contains some microphotographs showing the inefficiency of the manufacturer's annealing and the effectiveness of heat treatment. From a diagram giving the average results of a considerable number of tensile tests made from large castings it appears that the heat treatment increases the elastic limit about 50 per cent and the ultimate strength about 25 per cent, without any material change in elongation. The paper was discussed at some length by Messrs. Kone and John Howe.

In the afternoon session the following two papers were read by title, in the absence of the authors:

The American Steel Rail Situation, by R. W. Hunt; Manganese Steel Rails, by Sir Robert Hadfield. The latter paper was discussed by Messrs. W. S. Potter and J. W. Richards.

The paper on blast furnace operation with a turbo blower, by S. G. Valentine, was discussed by Messrs. J. W. Richards, L. Waldo, J. E. Johnson, Jr., and K. Nibecker, the latter two speakers questioning the accuracy of the instrument calibration on which the claimed results are based.

The three papers just mentioned may be found in full in the February issue of the *Bulletin* of the Institute.

Then followed three elaborate papers, of which a report must be reserved for the next issue on account of lack of space in the present number:

Gas Cleaning at the Duquesne Blast Furnace, by A. N. Diehl (the discussion bringing out much interesting information on recent developments at the Edgar Thomson Works).

Utilization of Blast-Furnace and Coke-Oven Gases for Power Purposes, by Heinrich J. Freyn (discussed by J. E. Johnson, Jr., R. Moldenke and R. Lyon).

Pig Steel from Ore in the Electric Furnace, by Robert M. Keeney (discussed by Dr. Richards).

The last paper of this session was presented by Mr. C. B. Murray, on the need of uniform methods of sampling Lake Superior iron ore, which was discussed by Messrs. Kelly and Sweetser.

Wednesday's Sessions on Mining Law

During the morning session Dr. J. A. Holmes presided.

The paper on The Disposition of Natural Resources, by G. O. Smith, was presented by the author and discussed by Dr. Raymond.

A paper by C. H. Shamel, "Should the Apex Law be Now Repealed?" was read in abstract in absence of the author, and was strongly criticized by Dr. Raymond, who objected with especial vigor to the proposal to have questions of fact decided by the U. S. Geological Survey and not subject to review by the courts. The arguments of U. S. Senator Walsh, of Montana, were in a similar direction.

This discussion was continued in connection with the paper by C. W. Goodale on "The Apex Law in the Drumlummon Controversy."

The morning session was concluded by the presentation of four papers by G. O. Smith, F. F. Sharpless, A. Burch and F. L. Sizer.

During the afternoon session the paper by Horace V. Winchell, who presided in the afternoon, was first presented on Why the Mining Laws Should be Revised. E. B. Kirby's paper on Mining Law Revision—How to Obtain It, followed. Senator Walsh, of Montana, finally gave a review of the present status of mining legislation at Washington. This elicited a general discussion, and it was again and again emphasized that to make a success of it the new code of mining laws should be drafted by experienced mining men who are also familiar with the law—not by lawyers.

Thursday's Sessions

During the morning simultaneous sessions were again held in different rooms. In one papers on mining geology were presented, while the other was devoted to a very interesting symposium on petroleum or gas. This was continued in the afternoon, while in another room papers on miscellaneous subjects were taken up. These were of a metallurgical character and will be reported in our next issue.

There was a general consensus of opinion as to the success and enjoyment of this meeting. The next general meeting of the Institute will be held in the autumn of 1914 in Salt Lake City, Utah.

Welfare and safety work among the employes of the Arkansas Valley plant of the A. S. & R. Co., at Leadville, was one of the features of the company's operations last year. A committee having the matter in charge meets weekly with heads of departments to consider the health and safety of employes, and to adopt measures to prevent illness and accident. This movement has proved satisfactory.

Transvaal Gold Production.—The number of companies reporting to the Transvaal Chamber of Mines in October, 1913, was 60. The total quantity of ore milled during that period was 2,127,085 tons. There were 9729 stamps in operation with an average duty of 8.62 tons per 24 hours. Tube mills in commission numbered 286. The yield for the month was 718,431 fine ounces gold.

Recent Chemical and Metallurgical Patents

Cement

Testing Portland Cement.—A convenient test of Portland cement which will effectually show the character of the cement as to permanency or durability when made into concrete is of great importance. **Mr. Howard J. Force,** chemist and engineer of tests of the Scranton laboratory of the Lackawanna Railroad, has devised an easy and reliable test, as follows: Briquets are made up of neat cement with a sufficient quantity of water to make a fairly plastic mass. These briquets are made in the usual brass molds having a cross-section of 1 sq. in., and are placed in a moist closet, where they are kept for 24 hours. At the expiration of this time a number of these briquets, usually three, are broken in a testing machine, and another like number of the same briquets are boiled under pressure for about 2 hours. The pressure is preferably about 20 atmospheres, or 285 lb. per square inch, which pressure is conveniently produced by placing the briquets in an autoclave or digester which contains water of about 70 deg. F., then closing the autoclave and then raising the temperature of the water by means of a gas flame or other suitable source of heat. It takes usually about an hour to reach a pressure of 285 lb., and this pressure is maintained for about an hour. Upon the expiration of this time the flame is extinguished and the pressure is blown off, which usually takes 20 minutes. The briquets are taken from the water, and if they have not been injured by the boiling they are placed in a moist closet for about half an hour. The briquets are weighed and the gain or loss in weight is noted and the briquets are broken in a testing machine.

It has been found that only cement which is sound in every way and suitable for producing a sound and lasting concrete will resist boiling under pressure successfully. Cements which will pass this test successfully are such as have been carefully manufactured by grinding the ingredients very finely, for instance, so that 85 per cent of the ground material will pass through a sieve of 200 mesh to the inch, then calcined or burned at a high temperature, for instance, 2700 deg. F., and then again ground to about the same fineness, or cements which are made of ingredients which have been thoroughly seasoned for several months after calcination. Inferior cements which are liable to produce unreliable concrete will crack or disintegrate when boiled under pressure or show a decided loss in tensile strength. Practice has shown that a pressure of 285 lb. to the square inch is very effective for producing the conditions which will bring to light the character or quality of the cement under treatment, but this pressure may be varied as circumstances may require. The pressure should, however, exceed 50 lb. to the square inch in order to produce the desired result within a reasonable period of time, and the higher the pressure is kept the quicker the desired result is reached.

One of the advantages of this process is that the briquets will be in condition for testing after a treatment of a few hours' duration. A satisfactory quality of cement will show a considerable increase of tensile strength after having been boiled under pressure, as compared with the same cement which has not been so treated, the increase being 25 per cent or more, and an unsatisfactory quality of cement will crumble or disintegrate under the treatment described. The tensile strength of the cement treated

under pressure should not be less than 400 lb. per square inch. The gain in weight by cement during the boiling under pressure should not exceed 1 per cent. The same test is also desirable for ascertaining the character of the cement with reference to expansion. For that purpose expansion bars are made of the cement mixed with water in the usual way with a cross-section of about 1 sq. in. and a length of about 6 in. The bars are placed in a moist closet and at the expiration of 24 hours are carefully measured. They are then placed in the autoclave and boiled under pressure as described, and at the end of that treatment are again measured. Cements which are constant in volume should not show expansion of over one-half of 1 per cent when tested under the above-described conditions. The pressures mentioned herein are measured from the atmospheric pressure as the zero. (1,085,977, February 3, 1914.)

Gold and Silver

Slime Filter.—A new modification of the drum type of filter for the continuous treatment of metallurgical slime has been patented by Mr. **Henry Alinder,** of Milwaukee, Wis., assignor to the Allis-Chalmers Mfg. Co. Fig 1 gives a central sectional view of the machine, while Fig. 2 shows an end view, partly in section, taken on the line III-III of Fig. 1. In brief, the filter consists of a revolving frame onto which are attached a number of wedge-shaped filter cells, arranged between the spokes of the drum. As the drum revolves in a tank of slime, the submerged cells are under vacuum which withdraws the solution and forms a slime cake on the filter surface. As the cell emerges it is put under reverse pressure, which dislodges the cake and throws it into another tank for a second treatment.

Referring to the figures, there are two drums, each in a separate tank 22 and 23, and revolving on hubs 30 and 31, fixed to the shaft 8. The filter cells 2 are constructed of porous material covered with canvas in the usual manner. Each has a pocket 5 connected

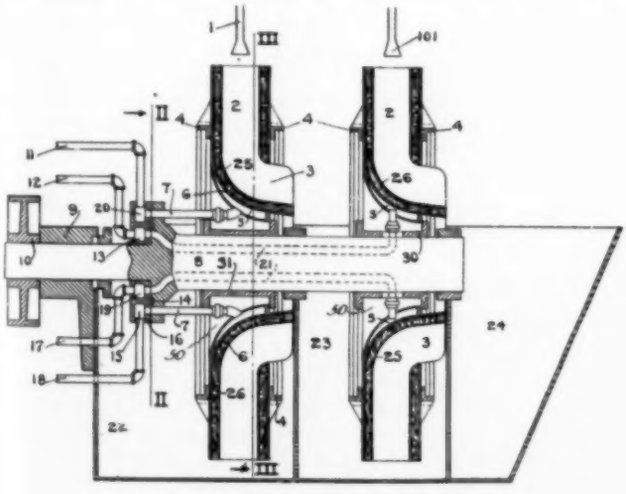


FIG. 1.—SLIME FILTER

by pipes 7 and 21, with sources of vacuum and pressure, so that the former can be applied to the submerged cells and the latter to those emerged. Each cell has a discharge opening 3, through which the dislodged cake is directed into the adjacent tank. Spray pipes 1 and 101 are placed conveniently to supply water for flushing the cake from the filter surface. (1,084,383, Jan. 13, 1914.)

Slime Agitator.—In Fig. 3 is shown a vertical view of a form of mechanical agitator patented by **Mr. Frank E. Marcy,** of Salt Lake City, Utah, and assigned to the Allis-Chalmers Mfg. Co. It consists of a conical bottom tank with a central vertical tube, as in the ordinary form of Pachuca agitator. Instead of using air as the agitating medium, however, the inventor arranges pumping means in a T attached to the lower end of the central tube. Slime can enter the T pipe from either end, where it encounters screw pumps which force the pulp upward through the lift pipe. The screw pumps are placed at 10 and 11 in the figure, and are actuated by a motor 16, pulleys 17 and 18, and shaft 6. If solids should tend to clog in the conical portion of the tank they can be dislodged by introducing air or liquid under pressure through the pipe 15 at the bottom. (1,082,431, Dec. 23, 1913.)

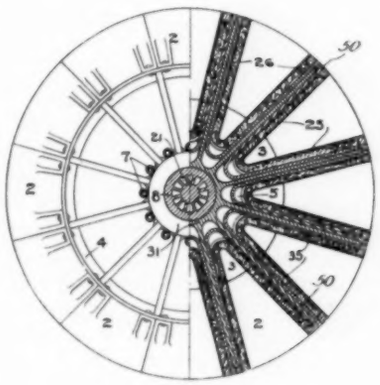


FIG. 2—SLIME FILTER

Copper and Zinc

Basic-Lined Copper Refining Furnace.—Improvements in the construction of reverberatory furnaces for copper refining are patented by Messrs. **Lawrence Addicks,** of Perth Amboy, and **Clarence L. Brower,** of Chrome, N. J. It has been customary heretofore to refine copper in a furnace having silicious walls and hearth with a cooling vault beneath. The silicious

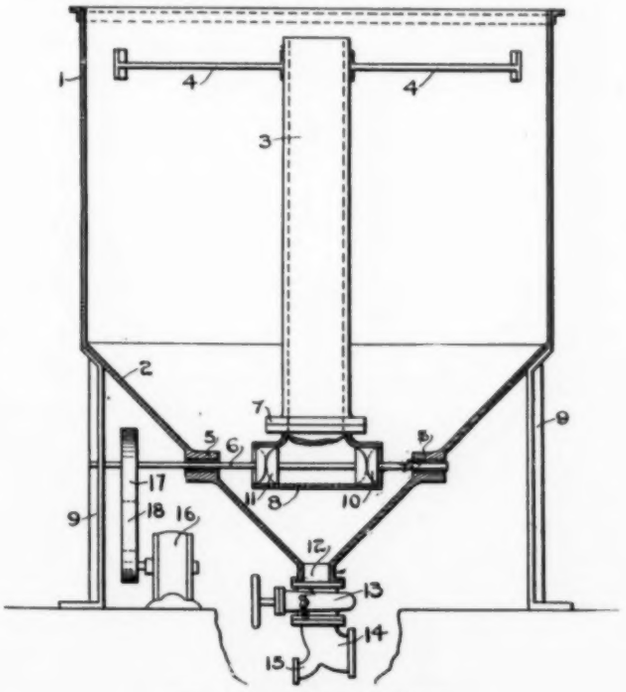


FIG. 3.—SLIME AGITATOR

lining has furnished the necessary acid ingredient to slag off impurities in the copper, but the slag formed has been excessive, and there has been danger to the furnace structure from the consumption of the silica lining. The present inventors make use of magnesia

brick in the hearth and chrome brick in the roof and walls, and find these materials superior to silica for the purpose. The furnace is constructed of a concrete and brick base, on which clay brick are laid in the form of an inverted arch. On this is laid the magnesite brick hearth, also in the form of an inverted arch, between skew-backs which receive the thrust and communicate it to the side supports. By a special construction the brick of the hearth are continued to the skew-back, beneath the side walls, and form a suitable base on which to build the walls. The magnesite bricks are laid in a mortar of magnesite dust and silicate of sodium solution.

Three classes of material ordinarily are dealt with in such furnaces: (1) Foul, such as junk, cement copper, etc.; (2) normal, such as blister copper from converters; and (3) pure, such as cathode copper. The basic-lined furnace is superior to the acid-lined furnace for the treatment of these materials. In the case of foul material the basic furnace permits separate treatment, with production of less slag and less danger to the furnace structure. In the case of ordinary blister copper the quantity of slag formed in the basic furnace is less than in one lined with silica. This is true also with cathode copper, where the slag formed amounts to less than one-half per cent with the basic furnace as compared with 3 per cent in the silica-lined furnace. Also, with the basic furnace

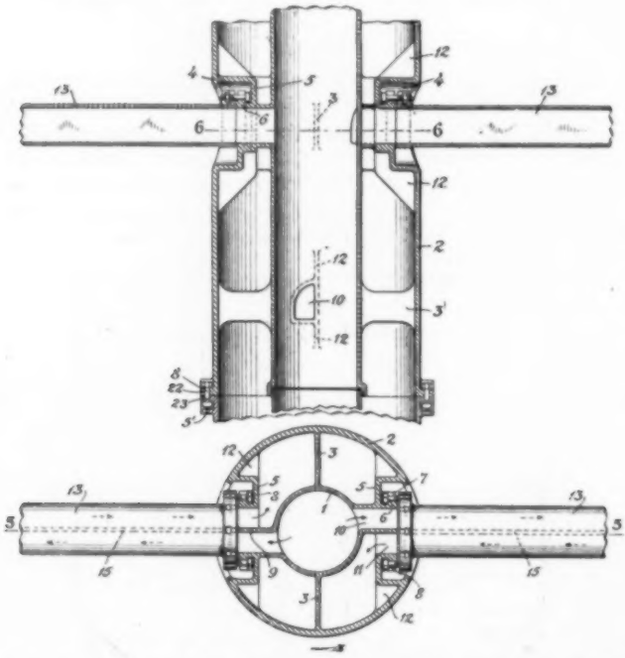


FIG. 4.—COOLING RABBLE ARMS IN ROASTING FURNACES

this pure material requires only melting, whereas in the acid-lined furnace the same cycle of operations is gone through as in treating blister copper. (1,083,719, Jan. 6, 1914.)

Improved Form of Zinc Retort.—The ordinary clay retorts used in spelter production are tubular in form and have appreciably flat surfaces on which slag dripping from a broken retort in an upper tier may lodge and ultimately puncture the wall and thus destroy an otherwise good retort in a lower tier. In order to obviate this destruction of retorts, Mr. **Harold W. Webster**, of Billericay, England, has patented a form having a sharp ridge along the top outside, resulting in increased thickness at this point and offering no surface on which dripping slag can lodge. The retort has a thickened and exteriorly flattened bottom which provides increased durability and a secure base for the support of the retort in the furnace. The rounded interior shape is preserved at both top and bottom of the retort.

Fumes

Mechanical Purification of Smelter Fumes.—The recovery of mechanical impurities and the purification of the gases in smelter fumes is the subject of a patent granted to Charles S. Vadner, of Salt Lake City, Utah. The patent, in fact, refers to an acid smelter fume filter. The inventor in Fig. 5 shows its application to smelter fumes in general. The fumes coming from the smelter flue are led through the intake flue 1 into the recovery tower A, which has a sloping bottom 1', sloping away from the intake flue, while above the entrance of the intake flue there is a grate made of chemical bricks, 3, with suitable apertures entirely across the base of the recovery tower. Resting upon these grates are a number of spherical bodies, 4, of suitable size and character. The opening of the grate, 3, is smaller than the diameter of the bodies, 4. In the center of the recovery tower is a rotary stirrer, 5, with stirring arms, 6, provided with a pulley, 7, or other suitable means for the operation of the same outside of the recovery tower. These spherical bodies completely fill the recovery tower, and are prevented from falling into the outlet, 9, by the grate, 3, which is composed of chemical bricks, insoluble in acids, set at suitable intervals across the opening in the outlet. The fumes percolating upward through the irregular apertures between the suitable spherical bodies lose all their mechanical impurities, which become disposed in the interstices between the spherical bodies. The rotary stir, 5, is rotated, and by agitating the spherical bodies the mechanical impurities, consisting of gold, silver and other valuable metals, are permitted to fall down through the spaces in the brick grate to the sloping floor, 1, thence they may be drawn off through a manhole and returned to the smelter for the recovery of their valuable constituents. In this way all mechanical impurities are intended to be filtered from the fumes, preparatory to their passage onward through the outlet into other gas-treatment apparatus, where any combustible gases contained therein and other values are to be recovered. (1085712, February 3, 1914.)

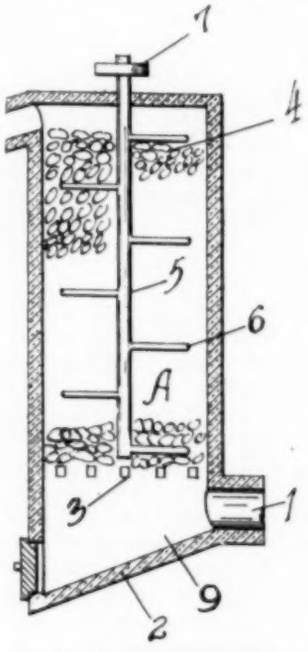


FIG. 5.—FUME FILTER

Metallurgical Furnaces

Cooling Rabble Arms.—In roasting furnaces of the superimposed-hearth type it is advisable to cool the rabble arms in order to increase the life and efficiency of the furnace. Mr. **John B. F. Herreshoff**, of New York City, has recently patented an improved form of construction in which the central rotating member and the rabble arms are efficiently cooled by currents of air. As shown in Fig. 4 the central rotatable shaft to which the rabble arms are attached, consists of a

central portion 1 and a concentric sleeve 2, held in concentric relation by strengthening ribs 3. At points of attachment of the rabble arms the walls of the sleeve 2 are recessed to form pockets 4. From the innermost walls of these pockets extend semi-circular flanges to which the rabble arms are attached by bolts. Each flange is provided with a vertical partition 9 which, together with the walls of the flange on one side of the partition, extends to the inner shaft 1 to form a passage 10. Each rabble arm is provided with a semicircular flange and with a central vertical partition from its inner end to a point near its outer end. Thus when the rabble arms are in place there is provided a continuous path for cool air from the inner portion of the shaft through one side of the rabble arm, back through the other side and into the inner portion of the shaft. The air current may be induced or forced in the usual manner. (1,085,419, Jan. 27, 1914.)

Convertible Crucible-Retort.—By the use of a particular type of crucible and cover in an ordinary tilting furnace, Mr. **Willis W. Case, Jr.**, of Denver, Col., has made an invention which permits the use of the furnace for melting or retorting as desired. (1,085,540, Jan. 27, 1914.)

Production of Thorium

A method of producing metallic thorium in a condition suitable for the manufacture of filaments for incandescent lamps has been patented by Mr. **William C. Arsem** and assigned to the General Electric Co. Metallic thorium hitherto produced has not been suitable for use as a filament, but according to the inventor's process it may be so produced. He converts thorium dioxide into thorium tetrachloride, and reduces this salt with sodium in a vacuum. The metal thus produced is washed and then compressed into a dense metallic state, from which hammered or drawn metal may be produced. (1,085,098, Jan. 27, 1914.)

Synopsis of Chemical and Metallurgical Literature

Iron and Steel

Sintering Iron-Bearing Materials.—The agglomeration or sintering of finely divided iron-bearing materials has become an important adjunct to the iron and steel industry, by rendering available for reduction in the blast furnace certain materials hitherto useless for that purpose. Thus, blast-furnace flue dust, finely divided concentrates and similar substances have been converted into a suitable blast-furnace feed. In the "Proceedings" of the Engineers' Society of Western Pennsylvania for December, 1913, Mr. B. G. Klugh presented the latest developments in this industry as exemplified in the Dwight & Lloyd process. This method of sintering was originally developed as a roasting process for sulphide ores in non-ferrous metallurgy, and is now widely used in that industry. Its extension to the iron field was a subsequent development, but is now recognized as an important means of agglomerating iron-bearing materials when mixed with a suitable proportion of fuel. There are now five Dwight & Lloyd plants in operation on iron materials, and thirty-eight in non-ferrous metallurgy. The iron plants treat pyrite cinder, flue dust, high-sulphur magnetites, magnetic concentrates, fine hematites, limonites and roll scale. For all except the flue dust it is necessary to add the requisite fuel.

The potent factor in operating this process is to maintain a permeable bed of mixture on the sintering hearth. This is affected by the quantity of water added, the method of adding the water and the method of delivering the mixture onto the hearth. The bed must be uniform in depth and consistency and the volume of gases passing through every square inch of bed should be progressively the same. Ignition is another important factor in efficient operation. Each mixture has an intensity of ignition for its most efficient sintering operation. Different fuels may be used. Of the five plants mentioned above two use fuel oil, two natural gas and one artificial gas. Fuel oil consumption is ¼ to ½ gallon per ton of product; natural gas, 60 cu. ft. per ton. Gasoline has been used and abandoned, but coal may be used advantageously under local conditions.

Early experience with the Dwight & Lloyd machines indicated a high loss of grate bars when sintering flue dust with a high fuel content, say 25 per cent. Since only about 8 per cent is necessary for sintering, the balance was burned out at the expense of the grates. Later this difficulty was overcome by covering the grates with a layer of lime or with coarse sinter which had been screened from the cake as it discharged from the machine.

While high-carbon flue dust can be sintered, it is considered advisable to use low-carbon material when possible. This can be secured either by concentrating the high-carbon dust or by diluting it with other fine material containing no fuel. The latter has been deemed the more profitable practice, although it is admitted that concentration yields a better material for sintering.

As examples of the value of sinter as a furnace feed, the author cites an Eastern furnace carrying a burden of 25 per cent sinter from flue dust and magnetic ore. With this charge the fuel has been about 10 per cent lower than before, when sinter was substituted for an old-range ore. There has been an absence of slips and scaffolds, and no action of scouring. A Southern furnace formerly carried a burden consisting of ¼ to ⅜ rotary kiln nodules, but never over ⅜ on account of scaffolding and scouring. Sinter has since been substituted and carried to the extent of one-half the burden, with a decrease in coke consumption, more regular driving and increased output.

In desulphurizing, the Dwight & Lloyd process has been successful in reducing sulphur in cinder from 2.0-6.5 per cent down to 0.10 per cent. Magnetite with 1.5 to 4 per cent sulphur has been reduced to 0.15 per cent.

The cost of operating a plant of two units is given in round numbers per ton as: labor, 18 cents; ignition, 6; repairs, 6; power, at 8.8 kw-hr. per ton, 16; total, 46 cents.

With cheap natural gas the cost for ignition would be only a fraction of a cent.

In the discussion it was brought out that material containing sulphur in combination with calcium and barium could be desulphurized to less than 0.1 per cent.

Weathered flue dust sinters better than fresh one. Different fuels can be used in the sinter mixture, as coke breeze, bituminous coal and anthracite screenings. In some experimental work charcoal, sawdust and lignite coal had been used successfully. Fuel containing sulphur does not affect the ultimate result in desulphurizing pyrite cinder. The quantity of air drawn through the bed is in excess of chemical requirements by from 50 to 80 per cent. The best pressure in 13 in. water gage.

It is preferable to use a constant-speed fan and regulate the permeability of the charge to conform to varying air requirements.

Gold and Silver

Flotation of Antimonial Silver Ore.—In the November, 1913, "Quarterly" of the School of Mines, Columbia University, Mr. **Donald G. Campbell** describes a study of flotation as applied to a silicious ore containing pyrite, stibnite, and sulphides and antimonide of silver totaling about 5 or 6 per cent. The mineral was finely disseminated through the gangue, and necessitated fine grinding for its liberation. The ground pulp was subject to treatment according to the minerals' separation process of flotation, being mixed with water, oil and acid, and agitated to form a froth containing the mineral concentrate.

The oils tested were cylinder and machine mineral oils; sperm, fish and whale oils; corn, cottonseed and rapeseed oils; China-wood oil; resin oil; pine and pine-tar oils. In different experiments the effect of varying the acid, rate of agitation and temperature were tested. The summary of results shows:

1. Pine-tar oil was the most effective froth producer, and was most efficient when used in quantities approximating 0.1 per cent of the ore.
2. Without acid the froth is non-selective; that is, gangue is floated equally as well as mineral. The amount of strong sulphuric acid that seemed to produce the best results was approximately 0.4 per cent of the ore.
3. For good extraction the peripheral speed of the agitator blades had to be from 100 to 1200 ft. per minute.
4. Extraction increased with increase in temperature, and less oil and agitation were necessary. The amount of gangue carried into the froth was greatly lessened at higher temperatures.

Copper and Nickel

Roasting Copper-Nickel Matte.—A study of some of the reactions taking place when copper-nickel matte is roasted is published by Messrs. **Edward F. Kern** and **M. H. Merris** in the Columbia School of Mines "Quarterly" for November, 1913. A summary of the results shows that in the analysis of copper-nickel materials copper may be separated from a sulphate solution by boiling with metallic aluminium in the presence of about 3 c.c. concentrated H_2SO_4 per 100 c.c. volume. When a mixture of nickel sulphide and copper oxide is heated small amounts of copper and nickel sulphates are formed when the temperature is between 525 deg. and 600 deg. C. Above 650 deg. C. these sulphates do not form, but cuprous sulphide and mixed subsulphide are formed; the higher the temperature the more rapid the formation of the cuprous sulphide. Nickel subsulphide is shown to be a stable compound, and does not react with copper oxide when a mixture is heated.

The roasting of nickel-copper matte proceeds slowly at temperatures below 600 deg. C. Above 730 deg. C. the matte becomes pasty and is not easily oxidized. The best conditions for rapid and complete roasting are, first roast for an hour at 450 deg. to 500 deg. C., with free access of air, in order to coat the matte particles with the thin film of oxide. The temperature can then be raised to between 675 deg. C. to 725 deg. C. Rabbling is necessary to prevent sintering of the mass.

Tin

Crushing Tin Ore with Nissen Stamps.—Comparative tests of the value of Nissen and California stamps in crushing Cornish tin ore were recently made at the South Crofty tin mine, Cornwall. The results are reported in the *South African Mining Journal* for Nov. 8, 1913. Two Nissen stamps were run against 10 California stamps which are in the South Crofty mill. The following data show the comparative performance of the two types of stamp:

	Two Nissen stamps	10-stamp S. Crofty
Weight of stamps (lb.)	2000	1050
Number of drops per minute	94	—
Height in drop (in.)	9	—
Mesh of wire screen	14	14
Tons of ore crushed (2000 lb.)	5.6	5.6
Hours run	6.50	3.25
Tons per stamp per 24 hours	10.33	3.75
Units of power per hour	7.85	20
Cost of power per ton crushed (pence)	5.46	6.96

Grading Analysis.

	Nissen Stamps		South Crofty Stamps	
	Dry Per cent.	Wet Per cent.	Dry Per cent.	Wet Per cent.
+ 20 mesh	3.6	3.5	2.7	2.2
+ 40 mesh	22.4	22.7	17.4	16.9
+ 60 mesh	9.9	10.9	8.5	8.0
+ 100 mesh	20.8	18.8	20.5	19.2
+ 150 mesh	10.6	7.0	8.0	7.1
— 150 mesh	32.7	37.1	42.9	46.6

The wet screen grading analysis, done to determine the amount of minus 200-mesh product produced, gave the following results:

Discharge	Nissen stamps	Sth. Crofty mill
+ 200	67%	61%
— 200	33%	39%

The Nissen stamps have also been run on Carn Brea ore, and the results of the different trials are given below:

Test No.	1	2	3	4
Weight of stamps (lb.)	2,000	2,000	2,000	2,000
No. of drops per minute	92	94	94	94
Height of drop (in.)	7	9	9	9
Class of screen used	Wire	Wire	Wire	Cornish
Mesh of screen	10	10	20	36
Aperture, in inches	.654	.064	.028	.028*
Tons ore crushed (2000 lb)	12.20	17.75	3.36	5.26
Hours run	12.38	15.76	4.39	7.46
Tons per stamp per 24 hours	11.82	13.5	8.76	8.1
Units of power per hour	7.62	7.85	7.85	7.85
Cost of power per ton crushed (pence)	4.63	4.18	6.54	6.93

*Approximate.

Grading Analysis

Test No.	1	2 Dry %	3 Dry %	4 Dry %	4 Wet %
+ 20 mesh	*	13.1	—	—	—
+ 40 mesh	*	23.1	14.0	5.4	5.1
+ 60 mesh	*	9.8	10.9	13.3	12.9
+ 100 mesh	*	19.9	24.2	28.1	27.3
+ 150 mesh	*	8.9	12.5	10.5	9.4
— 150 mesh	*	25.0	38.4	42.7	45.3

*No samples taken.

The tests with Nissen stamps, we are informed, were all very much interrupted through lack of water, and it is considered that with regular running still better results would be possible. The result of the test in which a Cornish screen was used is regarded as particularly satisfactory, the screen analyses showing a much more granular pulp than usually obtained in Cornwall. This goes to confirm the opinion held by the inventor and manufacturers of the Nissen stamp that this mill would give not only an increased output at a lower cost for power, but also contribute to the securing of a higher tin recovery ratio, inasmuch as it would produce less slimes.

Cement production in the United States in 1913 amounted to about 92,406,000 barrels, according to preliminary estimates of the Geological Survey. This is an increase of about 12 per cent over 1912. The average value per barrel is considered to be appreciably higher than in 1912. Increases of 10 to 25 cents per barrel have been reported from Rocky Mountain plants.

Bureau of Mines publications recently issued include **Technical Papers** 50, on metallurgical coke; 54, on errors in gas analysis due to assuming molecular volumes of all gases alike; 58, on the action of acid mine water on the insulation of electrical conductors; and **Bulletin** 58, on fuel briquetting investigations.

Pressure Air-Cooled Roaster Furnace

The new Herreshoff pressure air-cooled roasting furnace has been brought to the attention of the metallurgical world within the last two years, although the furnace in its present development has been in use in acid works for a long time.

The furnace has been developed as the result of experiments with various sulphide ores for the purpose of making sulphurous acid gas. These experiments were conducted under the able direction of Dr. J. B. F. Herreshoff with the idea of designing a furnace which permits the use of higher temperatures than heretofore thought possible, without localizing a heat of such intensity as to endanger the slagging of the ore body, or destroying the working parts of the furnace.

To attain the above results, a long series of experiments were carried on, using such well-known cooling mediums as water, partially water and partially air, but these were found unsatisfactory in producing the ultimate results desired. The pressure air-cooled system was then adopted as it performed all the necessary functions, and at the same time simplified the construction and operation, to say nothing of permitting the utilization of waste heat.

The pressure air-cooling effect in the furnace is obtained by forcing air at 1 oz. to 3 oz. pressure by means of a fan, into the bottom part of the shaft, which conveys it to the arms, and thence in its heated state to the ouside air, or to the bottom hearth of the furnace for combustion, or both.

The shaft is made double, similar to any jacketed vessel, the outer shaft or tube being made of cast iron, the inner one of cast iron or steel. The rabble or rake arms are also made with this double effect, the inside tube of the arm connects with the inside tube of the shaft, while the outside tube of the arm connects with the outside tube of the shaft. The air supplied by the fan enters the main tube of the shaft, passes through the inner tube of the arm, thence through the outside arm and shaft tubes to the top of the furnace. Here it is either discharged to the open air, at temperature of about 400 deg. Fahr., or carried to the bottom or cooler parts of the furnace for combustion, either through the temperature control flues or the bustle pipe, or both.

The temperature control flues in combination with the bustle pipe and return pipes for waste heat perform two very valuable functions. The temperature control flues absorb the excess heat from the hottest zones of the furnace, and transmit it to the cooler ones; the return pipes take the waste heat from the top of the furnace and discharge it at the bottom or cooler zones of the furnace for combustion purposes.

It is plainly comprehensible, and has proven out by actual practice, that the embodiment of these two features will give a maximum capacity of sulphur per square foot of hearth area, without endangering the slagging of the ore body, due to localization of an intense heat in the central zones of the furnace.

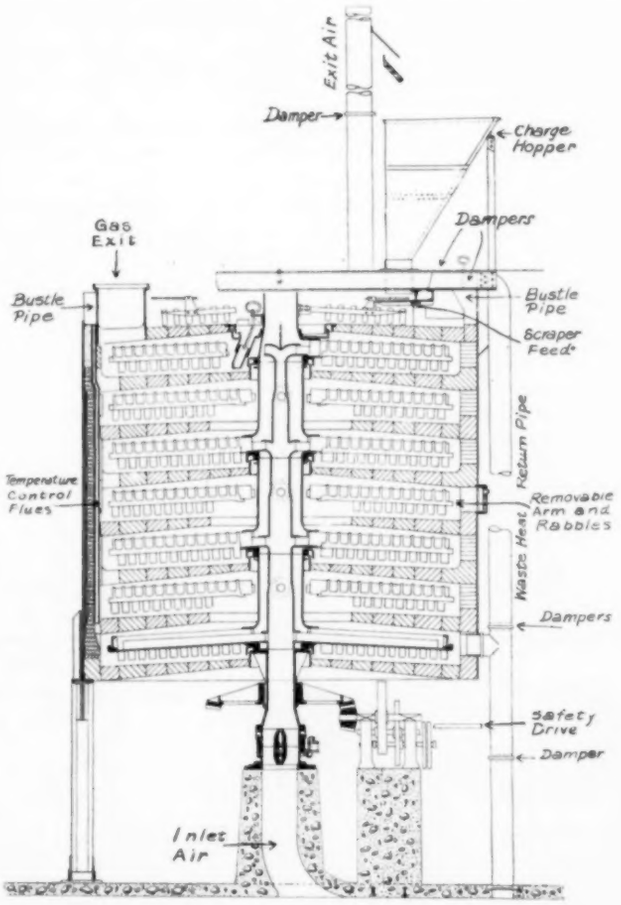
A detail feature which applies in our furnace is that the amount of air necessary to give sufficient cooling to the shaft and arms is approximately the amount necessary for combustion, making the temperature of the waste heat to be returned a maximum, thus giving the greatest efficiency for the utilization of the same. The damper control makes it possible to use just as much of the waste heat as desired, so that the control is flexible, making the furnace adaptable for burning various grades and quantities of ore within reasonable limits.

The removable rabble arms are made of standard steel pipe which makes them light for handling, and easily attainable at small cost, and their durability has proven superior to cast iron under actual working conditions.

The removal of the arms has proven by experiment a very simple and rapid operation, the same being performed on a hot furnace.

The removable rabble teeth are so designed, in regards to their pitch and progression, that they maintain a uniform thickness of ore bed over the entire hearth surface, and by means of the back and forward rabble effect the surface of the ore exposed for combustion is greatly increased.

These two features, the former permitting the ore to remain the greatest length of time in the furnace and



HERRESHOFF AIR-COOLED ROASTER FURNACE. (TYPE SHOWN IS OF MEDIUM SIZE, SPECIALLY ADAPTABLE FOR A DEAD ROAST)

the second exposing a larger surface for combustion, mean maximum capacity with thorough desulphurization.

The openings for the passage of the gas between the hearths are designed so as to reduce the velocity of the gas to about 270 ft. to 300 ft. per minute, about one-third of the velocity found in most furnace designs, thus preventing the formation and entrainment of dust.

The ore feed is a very important feature. This is composed of a telescopic device attached to the hopper, which feeds the ore in a cone-shaped pile to a plate. From here it is scraped by knife edges, attached to the revolving drying hearth rabble arms, and when once set this simple indestructible feed delivers a constant quantity of ore to the hearth without further regulation. The ore then passes across the top of the drying hearth, in a thick or thin bed, as desired, according to the moisture in the same, and the variation of the speed

of travel can be regulated by adjusting the relative position of the rabble teeth.

From the drying hearth the ore passes onto the furnace proper through a telescopic feed which also acts as a gas seal. This feed and dryer has proven very efficient in furnishing the furnace with a constant quantity of thoroughly dried ore which is essential for good operation.

A few words in regard to some of the details of construction may prove of interest. The shaft, lues, etc., are designed so that they are easily removable and wherever wrought iron or steel is used, it is either air-cooled or properly protected.

The bearings top and bottom insure perfect shaft alignment, and are so constructed that the horse-power for operation is reduced to a minimum.

The patent safety drive insures the rabble arms, teeth and shaft from breakage, should any foreign matter block the arms.

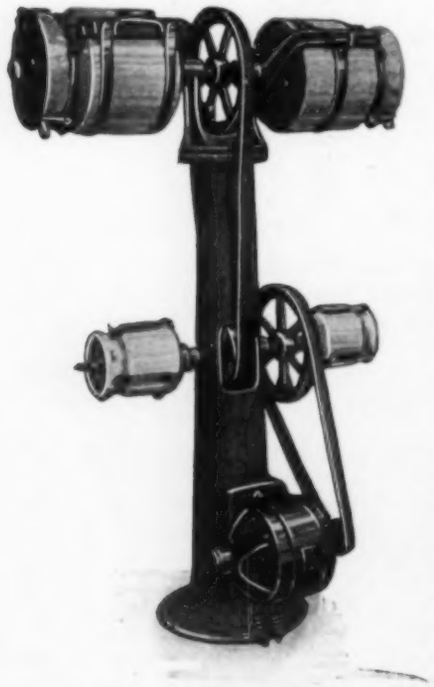
The furnaces are equipped with a sufficient number of specially designed doors, which are built for stability and convenience of operation. They are nicely machined and provided with sight holes, which are self-locking, making a gas-tight apparatus, not like the ordinary door which is not tight at the beginning, sulpates in a short time, and lets so much gas escape that the burner room, which should be a pleasant place to work, becomes a very disagreeable one.

In this article we have confined ourselves to points which apply on all furnaces, whether they are for a dead or metallurgical roast, and these principles also apply where extraneous fuel has to be used.

This furnace was developed by the General Chemical Co. through its Herreshoff Furnace Department.

Laboratory and Sample Mill

The Abbe Engineering Company, of New York City, has added another mill to their large line of machines by putting on the market their combination laboratory and sample mill. This is really a combination of various sizes of their laboratory mills, fitted to a stand which makes a machine that is easily accessible from all sides, and being self-contained, may be placed in any part of a laboratory.



LABORATORY AND SAMPLE MILL

Where different diameter jars are used different speeds are obtained by means of belts and pulleys or silent chain gearing. A large number of different sized jars can be mounted on this type of machine, according to the requirements.

A novel feature is the motor fastened to the shaft of the column. This motor may be run from any commercial electric supply circuit and can be fed from any electric light socket. Another feature is that the mill being on its own arm pedestal a separate stand or table is not required. This also avoids the discomfort of stooping to change jars, when the mill is on the floor. When it is not desired to run the machine with a motor a pulley is furnished which may be belted to a line shaft.

New Base-Metal Thermo-Couple

A new type of base-metal thermo-couple has just been put on the market which has several decidedly novel features of construction. The most frequent source of complaint of the ordinary base-metal couple emanates from its lethargy in indicating fluctuations. This has been due to the protection given the couple itself. Ordinarily this protection consists of an iron or steel tube through which the heat must travel and then heat the air within before it reaches the active portion of the couple, which in turn acts upon the instrument indicating the temperature.

In some cases this lag has amounted to 30 minutes, meaning that the actual temperature could not be read until 30 minutes had passed after exposing the couple to the heat of the frnace. This is about as bad a case as depending upon a watch which gets you to the depot 30 minutes after the train has left.

This great objection has been overcome in one type of couple by enclosing one of the elements in the second one, which is of tubular shape. The elements are welded together at the end and the couple

BASE-METAL THERMO-COUPLE CONSTRUCTION

is used in this form mostly without additional protection, making it thereby an exposed couple. But the products of combustion are liable to attack the couples and rapidly oxidize the exposed portions, and especially when immersed in molten metals the interior wire or rod, which is supposed to be the protected element of the couple, is gradually eaten into from the small portion of its exposed end.

The new "simplex couple" brought out by the Stupakoff Laboratories of Pittsburgh combines the good qualities of the two types just described, and at the

same time eliminates objectionable features. While the solution is exceedingly simple, it is unquestionably effective. It is accomplished by introducing as a new feature an internal weld, which forms the point of junction between the two elements of the thermocouple. One of the elements is a rod or a wire, and the second one, inclosing it, is of tubular form. A button consisting of the identical material as that of which the outer element is made is welded to the inner element, and after introducing this into the outer tube the head of the button is welded to the open end of the latter. Thus, the junction itself remaining at the very end, the completed entity represents a typical form of the exposed couple.

The accompanying illustrations, which are copies of drawings accompanying the application for United States patent, now pending, plainly show the various steps followed in the manufacture of this new device and need no additional explanation.

A New Chemists' Slide Rule

BY HARRY R. LEE

The Keuffel & Esser Company, 127 Fulton street, New York City, have recently placed upon the market a new type of slide rule especially designed to meet the needs of chemists engaged in commercial analysis. The designer of this excellent rule and the author of the manual which is issued in connection with it, is Dr. R. Harmon Ashley, of the Chemical Department of the University of Maine. As the name implies, it may be used in the solution of any problem in stoichiometry within the list of elements and compounds printed on the rule.

Referring to the usual engineers' slide rule for nomenclature, the regular or front side of the chemists' rule shows the molecular symbols of 46 salts and 10 acids and bases on the A scale of the frame and a parallel list of these on the B scale of the slide. On the back appear the symbols of 42 elements and 37 oxides in place of the usual A scale on the frame, and a parallel list of these on the B 1 scale of the slide. The C and D scales on the front and the C 1 and D scales on the back are graduated numerically as is usual on the engineers' slide rule.

The principle of the application of the rule to the handling of chemical symbols and the corresponding atomic and molecular weights is clearly understood after passing the runner to a few of the elements on the A scale and reading under the runner on the D scale; in each case it will be seen that the atomic or molecular symbol with its graduation exactly corresponds in position with the proper atomic or molecular weight as numerically expressed on the D scale. The elements and compounds are, therefore, arranged in a list according to the ascending numerical values of their atomic and molecular weights and in no way does this arrangement depend upon alphabetical or chemical grouping. The symbols sought are located by approximate knowledge of their weights.

FIG. 1—FRONT OF CHEMISTS' SLIDE RULE

As in every application of the slide-rule principle, the distance of each symbol graduation from the left-hand index-line of the rule is proportional to the logarithm of the numerical value of the weight corresponding to the symbol. Salts and oxides are provided with short graduation lines, while acids, bases and elements have longer lines; this, with a little familiarity with the instrument, enables the operator to identify the line of the symbol for which he is looking, especially where approximately equal atomic or molecular weights of different substances necessarily crowd the graduation and printing.

The symbols listed comprise about all which will be needed by the chemist in ordinary commercial practice and is a remarkably good selection for the purpose. Those who need many symbols not given on the rule will for the most part be chemists working in the rarer elements and compounds, the nature of whose work will call for closer methods of calculation than a slide rule could possible afford.

In those cases where a molecular weight has not been inscribed on the rule, it is often possible to read off the weights of two, rarely more, compounds, the sum of which will give the molecular weight desired. Setting this sum on the proper numeral, the rest of the calculation will proceed as usual.

The sacrifice of the A and B scales on the front and of the A and B 1 scales on the back side of this rule to make space for the chemical symbols is the only way to effect the purpose of the designer. Those who will miss these features will recollect, however, that stoichiometrical calculations do not involve squares and cubes, or the corresponding roots and will turn to an engineers' rule for this class of calculation.

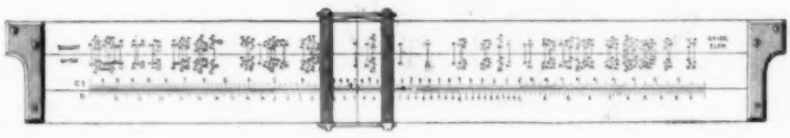


FIG. 2—BACK OF CHEMISTS' SLIDE RULE

The rule will assist in the solution of any stoichiometrical calculation, but is more particularly adapted to save time in handling the simpler ones, where most of the terms of the written expression are found to be molecular or atomic weights. In the extreme case of gas volume evolved from a reacting solid substance, the expression will involve the molecular weight of the latter, the gas factor 22.4, two temperature factors and two pressure factors, the result being the volume of gas at a prescribed temperature and pressure from a given weight of reacting solid. In this case 5 of the 6 factors being numerical and known, an ordinary slide rule would do nearly as well, with reference to convenience or time consumed, the rule furnishing only one chemical weight.

A feature of the rule which will appeal to some, who do not make a point of remembering the atomic and moleculer weights of a large list of elements and compounds, will be found in the fact that the numerical value of any of the 135 symbols listed may be read off on the scales D by the use of the runner, accurate to the first decimal place at least, depending on the region of the scale where the value may be found. For ordinary purposes the exact knowledge of the second decimal figure is unessential, and this will change yearly for many elements as new determinations are published. No changes of sufficient magnitude will occur, however, to place the rule out of date and it is built to last a lifetime of good care.

The manual is a pamphlet of 25 pages, written in a

singularly clear and simple style, intelligible to those who have no acquaintance with the properties of logarithms and brief and clear enough to meet the needs of the technical man who wishes to know in the least time what he can do with the rule. The manual ends with a neat dissertation on the maximum error necessary in reading on three regions of the scale, which is unusual and gratifying to note. It is emphasized that the results from the rule are of as high order of accuracy as the chemical work which precedes its use, usually is expected to be. The reciprocal method of calculating any percentage is unique and very neat.

Holcomb Rock, Va.

A Self-Cleaning Screen for Sewage and Trade Wastes

In order to dispose of sewage and trade wastes in a sanitary manner, unusual efforts have been exerted to meet these requirements by a successful separation of the solids contained in the sewage and the clarification of the effluent to such a condition that it can be discharged to streams without polluting them.

FIG. 1—RIENSCH-WURL SCREEN IN SERVICE

To accomplish this, various tank treatments have been devised. Septic tanks, plain sedimentation, and more recently Imhoff or Emscher tanks have all had more or less vogue with engineers and have all proven to have more or less objectionable features, or to develop such objectionable features under conditions of service. In consequence of this the demand has been growing for an immediate system of treatment that would provide for the recovery as a by-product of the values contained in sewage, and be also suitable for like purposes in the industrial field.

The Riensch-Wurl rotating self-cleaning disc screen has proven a mechanical device capable of successfully accomplishing the desired results. This screen has been developed in Germany as a result of persistent experimenting to produce a fine screen that would automatically clean itself as well as collect a very large amount of the floating and suspended matter in the sewage and deliver the screenings in a sufficiently dry condition to be readily handled with a spade or conveyor system.

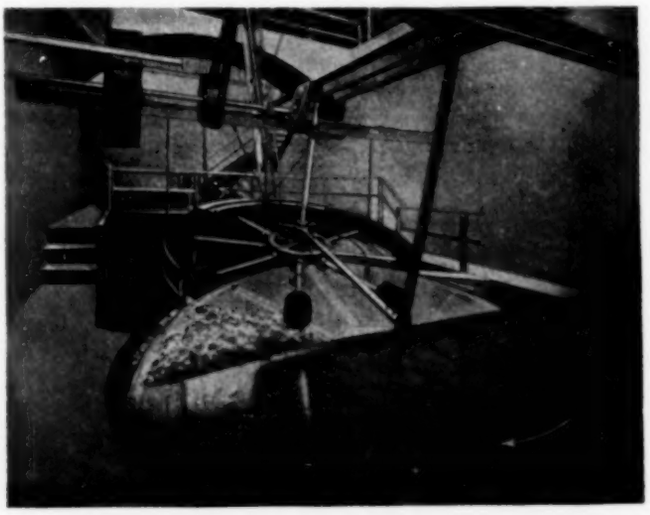


FIG. 2—RIENSCH-WURL SCREEN IN SERVICE

The screen consists of a perforated disc, set at an angle of 10 deg. to 25 deg. to the flow of the sewage, and revolving slowly on a shaft normal to the disc. The solids carried to the screen collect on it and are carried above the surface of the sewage by the rotation of the disc and there allowed to drain, after which the face of the disc is swept by a set of revolving brushes carried on a "star" driven by a shaft parallel to the shaft of the disc. As each portion of the screen surface is swept five or six times

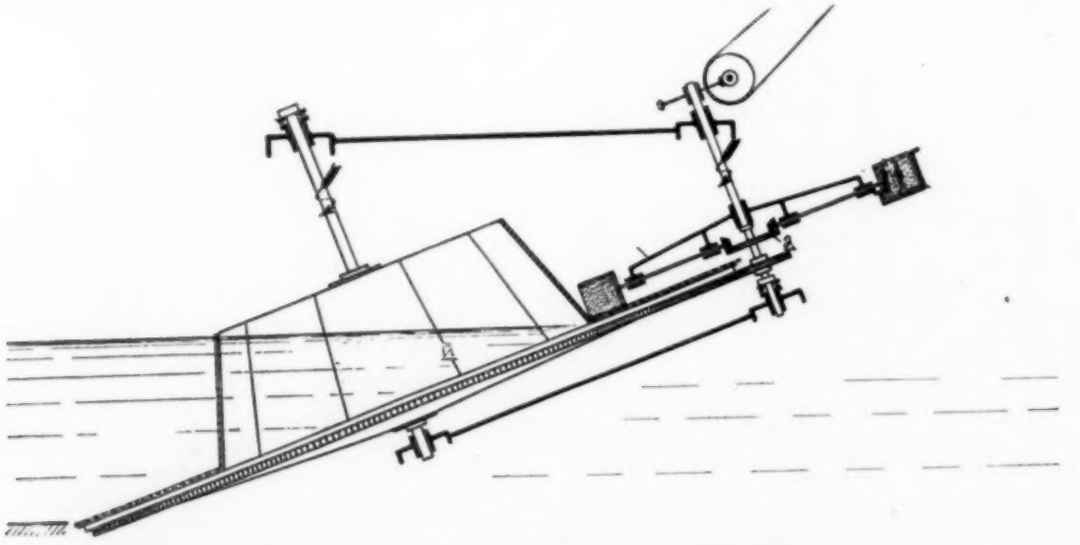


FIG. 3—ELEMENTARY OUTLINE OF RIENSCH-WURL SCREEN

by the brushes the result is a thorough cleaning of the screen plate. These screens are made usually with apertures of 2 mm. (5/64 in., or 79 mils) wide by 30 mm. (1 3/16 in.) long, but are sometimes fur-

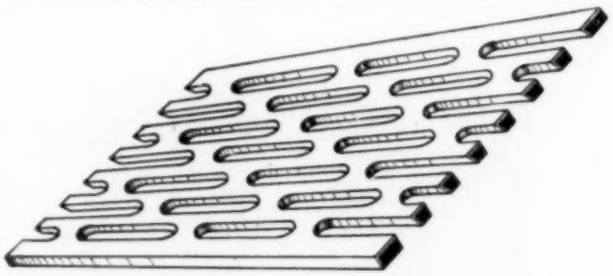


FIG. 4—SECTION OF RIENSCH-WURL SCREEN

nished with apertures or slits 1½, 1, or even ¾ mm. (59, 39, 29½ mils) wide.

The general appearance of this screen is shown in Fig. 1, while Fig. 2 shows a screen in which the central conical screening surface is omitted, but the method in which the screen operates is clearly shown.

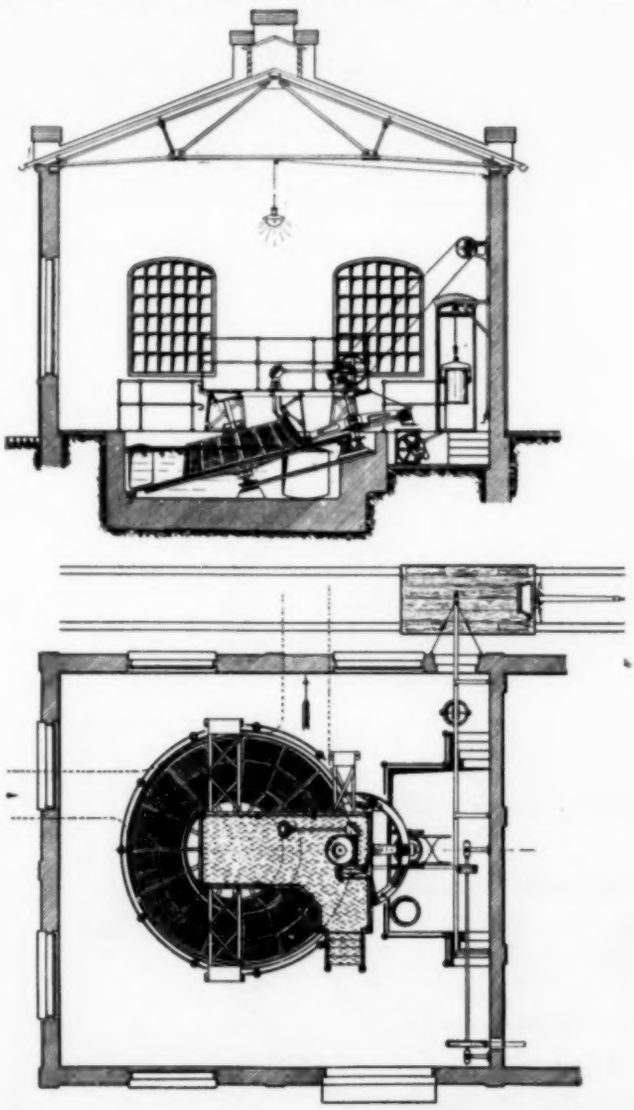


FIG. 5—TYPICAL INSTALLATION OF RIENSCH-WURL SCREEN

The arrangement of the machine will be better understood from the drawing, Fig. 3, while the screen plate is shown in Fig. 4, the tapered openings of which are varied to suit the particular requirements of service to be rendered.

Figs. 5 and 6 are typical installations of the screen alone and with pumping plant, while Figs. 7 and 8 show interior view and layout of the sewage treatment plant at Dresden, Germany, containing four screens, 8 meters in diameter.

The Riensch-Wurl screen is now being introduced in this country by the D'Olier Centrifugal Pump & Machine Company, of Philadelphia, after an extended stay of Mr. William L. D'Olier in Europe, where he studied and invesigated foreign sewage-disposal apparatus and processes.

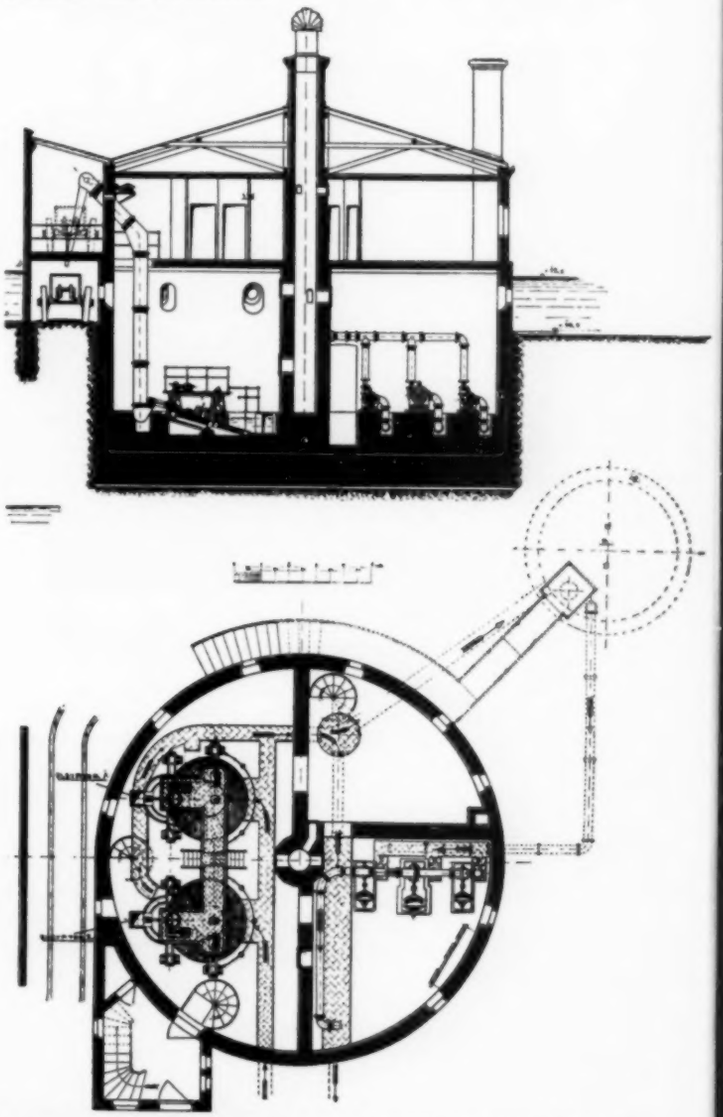


FIG. 6—TYPICAL INSTALLATION OF RIENSCH-WURL SCREEN AND PUMPING PLANT

The Riensch-Wurl screen is not only successfully and satisfactorily clarifying sewage and producing an effluent which is permitted to be discharged directly into the public waters of European countries, but is also removing the solids in the form of so-called sludge with such a minimum content of water as to render this easily handled and transported and in such a condition as to insure a maximum recovery of by-product in grease and degreased sludge, insuring actual financial returns from the operation.

In the process of handling sludge from various tanks, drums and from the Riensch-Wurl screens, a further reduction in water content is necessary, and a continual effort has been made to produce a machine which would successfully accomplish this

service. In Fig. 9 is shown a sludge reduction machine, capable of reducing from 98 or less percentage of water to approximately 55 per cent, greatly facilitating the final disposition of handling or reworking of the sludge.

FIG. 7—INTERIOR OF DRESDEN SCREENING PLANT SHOWING FOUR RIENSCH-WURL SCREENS

The perfection and adaption of these machines renders the mechanical treatment of sewage entirely feasible and designs are now under way for a number of plants in the United States.

The broader application of these screens in various industries should be appreciated with their growing use in the sewage disposal field. Wherever it is necessary to remove the solids from a large content of water, and where a process of screening is required, whereby the screening surface shall be continually kept clean and prevented from clogging the Riensch-Wurl screen should be found useful. Such

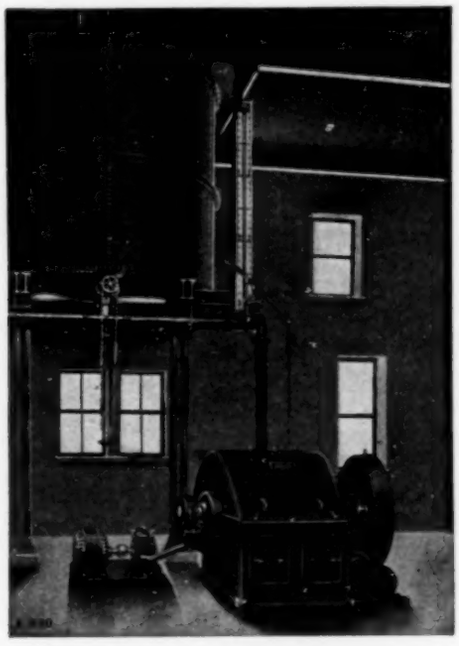


FIG. 9—D'OLIER SLUDGE REDUCTION MACHINE

industries as tanneries, slaughter houses, breweries, abattoirs, beet-sugar factories, pulp and paper mills, woolen mills, bleach works, and numerous other industries, should find in it, not only a simple method of recovering as a by-product, values formerly lost, but these industries would thereby be enabled to anticipate the growing demand for the protection of the streams by the clarification of the waste water from these industries before it is allowed to enter the waters.

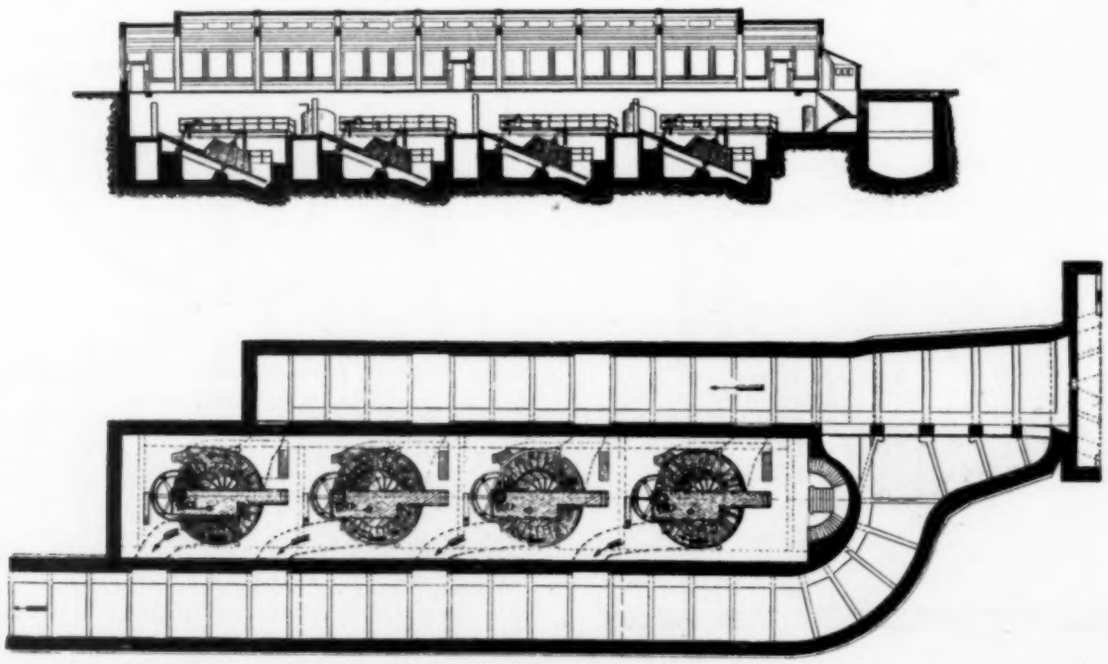


FIG. 8—PLAN OF DRESDEN SCREENING PLANT

Apparatus for Determining the Hardness of Metals by the Brinell Method

The hardness can be determined in different ways. The simplest consists in cutting the metal to be tested by another metal or in determining the pressure which must be exerted on a diamond when cutting a smooth surface by passing it across the surface of the metal under test. Thus the file is often used to ascertain the hardness of steel.

However, these are distinctly laboratory methods; they require a well-polished surface and the use of the microscope, and are slow. Like the use of the file, moreover, they are not sufficiently reliable, the results depending on whether the file used is more or less blunt or sharp.

The Brinell method does not present any of these disadvantages. Brinell impresses a ball of hardened steel into the metal to be tested under a given pressure. He measures the diameter of the indentation made by the ball and determines the area of the spherical cup thus formed. By dividing the pressure exerted by the area he obtains what he calls the hardness number.

The same ball being pressed into different steels under the same unvarying pressure will embed itself to a different degree, thus determining in a regular manner the hardness of the piece. It is easy to read the impression of 1 mm by means of an ordinary magnifying glass, and one can say that each tenth corresponds to a given degree of hardness. The effect on the hardness of steels of different quenching agents for the same temperature, or for different temperatures, can thus be easily followed. It is even possible to determine the uniformity of a treatment by repeating the test in different places. Moreover, this test can be very quickly made—in less than one minute—on the finished product, without injuring same and without the necessity of making test pieces from the part.

FIG. 1.—HARDNESS TESTING MACHINE READY FOR TEST

The advantage of the ball test is at least just as great when testing case-hardened pieces.

A very convenient apparatus for applying the Brinell method is the Derihon portable hardness testing machine, by which an impression is made with a 10-mm ball under a pressure of 3000 kgs.

Fig. 1 shows the machine ready for the test with the lever raised and resting on the shaft. The piece to be tested is placed on the table of the machine, which is then raised until the piece is in contact with the ball. This done, the lever is pulled slowly over so as to give a progressive pressure (the pressure is registered by a small manometer) until 3000 kgs are applied. When this figure is reached the lever is

FIG. 2.—PORTABLE HARDNESS TESTING MACHINE

slowly returned to its former position and the test is completed.

Under normal conditions it is usually sufficient to move the lever through an angle of 45 degrees to obtain the required pressure of 3000 kgs.

With each machine a small piece of steel is furnished in which a standard impression has been made, the size of the diameter being stamped on the same. This standard piece is of BND steel, an air-hardening chrome-nickel steel.

The accuracy of the machine can be easily controlled by making an impression alongside the standard impression.

The construction of the machine is based on the principle of elasticity of the frame, which for this purpose has been given the shape of a horseshoe.

The power produced by the pressure of the ball on the test piece has a tendency to open the frame to a certain degree in proportion to this power. The shape of the frame has therefore been specially considered in order to have it as elastic as possible.

The pressure exerted of 3000 kgs does not at all change the resistance or elasticity of the frame seeing that it is made of BND steel, having an elastic limit of 242,000 lbs. per sq. in., and that a pressure of 3000, 4000 or 5000 kgs does not work it above 10 kgs per sq. mm. (1442 lbs. per sq. in.). Under these conditions repeated tests even in large numbers do not alter at all the calibration of the machine.

The deflection of the frame being relatively weak (1 to 1.5 mm.), a register, the construction of which resembles a metal manometer, is installed in the hollowed-out part of the frame.

By means of a needle and a graduated dial the deflection and, therefore, the pressure exerted on making the test can be quickly and easily read.

To adjust the machine all that is necessary is to open the case enclosing the mechanism above the frame.

Should the machine ever get out of adjustment a

comparison should be made on the standard piece, and when an impression of the same diameter has been made the needle is brought over the figure 3000 by means of a small adjusting screw.

This adjustment, however, would only be necessary through some accidental cause independent of the operation of the machine under normal usage.

Fig. 2 shows the machine packed in its portable case. This machine is placed on the market by H. A. Elliott, 507 Majestic Building, Detroit, Mich.

Anti-Corrosion Pickling Chains and an Acid-Pump Casting

The life of forged chain used for handling material in pickling baths varies for the part submerged in or subjected to the action of the acid and fumes from eight days in the most exposed locations to a possible month under favorable conditions. Many methods of

TWIN-CYLINDER CASTING FOR ACID PUMP

treating such chains have been tried out, but all externally applied protectors broke or wore off at the point of contact of the links, and added but little to the life of the chain.

Substitution of special acid metal chains for the iron ones was proposed, and found to give perfect satisfaction. Many of these chains have been in service for periods of from two to four years and have needed repair only when worn out.

Casting of such a chain offered many difficulties on account of the size, and the tendency for the links to cast solid. At the Morgan Engineering Co., Alliance, Ohio, where chains of this kind are now made, a four-quarter mold, built up of core sand and baked, has finally been designed. The alternate links were cast separately in ordinary molds and finished before being fitted into the molds for connecting, and the joining links cast around them. This method insures sound links and obviates the forming of blow holes found when it was attempted to cast the chain at one pouring.

The subjoining illustration shows a twin-cylinder casting for an acid pump made in the foundry of the same company. This casting is of unusual size and complexity and was the first of a lot of three pumps for handling large quantities of diluted acid and dirty water.

The casting required metal from three crucibles and when thoroughly cleaned up weighed 1680 pounds. No blow-holes or other irregularities were encountered in cleaning up the casting, and it was found that the metal averaged closely to the same analysis throughout, showing that the three meltings were the same and the heats similar. All the mechanism of the pump is to be of the same acid-resisting metal, preventing any damage to the pump through corrosion.

Weighing and Regulating the Continuous Flow of Materials on Conveyors

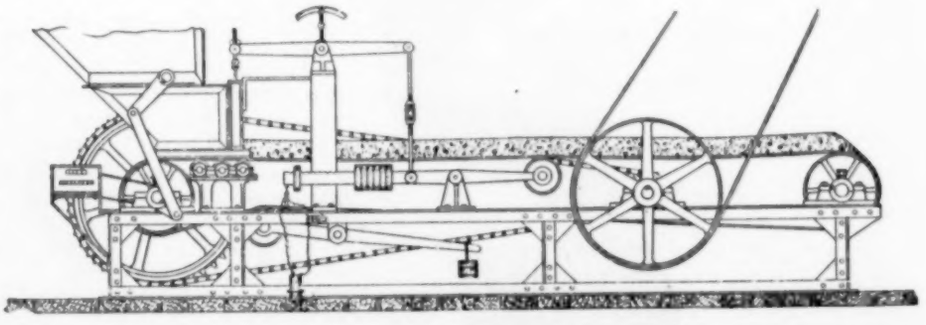
The adjoining illustration shows the Schaffer poidometer, built by the Schaffer Engineering & Equipment Company, of Tiffin, Ohio. This machine weighs and regulates the flow of materials traveling in a continuous stream over a conveyor. It can be attached to a hopper, bin or elevator spout, and delivers the material in any predetermined quantity at an even, regular flow, and records the amount handled, regardless of changes in specific gravity, amount of moisture or size of materials.

An interesting application of this machine which indicates the wide limits of its possibilities is in a clay products factory, where it adds manganese in proportion of one-half of 1 per cent and delivers the material at the rate of 2 lb. per minute.

The machine consists essentially of an endless belt traveling over pulleys and idlers similar to the method used in regular conveyors. One of these pulleys connects to the regulating and recording mechanism at the bottom of the containing bins.

In cases where it is desired to mix a number of different materials there is provided one machine for each of the materials, and each machine will deliver the desired proportions in a constant stream and insure an even mixture. This machine may also be used to advantage where moisture is to be added to materials in certain quantities.

When materials are put up in batches a special attachment is provided which controls the machine for any desired amount, and when the desired quantity



MACHINE FOR WEIGHING AND REGULATING THE CONTINUOUS FLOW OF MATERIALS ON CONVEYORS

has been delivered the machine automatically stops and again sets itself in operation at the proper time.

The materials handled by this machine should be either in powdered or granular form, but a certain percentage of large lumps, up to 1¾-inch mesh, does not interfere with the proper performance.

The Application of Producer Gas to Glass Factories

For the past two years the Chapman Engineering Company, of Mt. Vernon, Ohio, have been making a special study of the application of producer gas to the glass-making industry. The problem, viewed from a practical standpoint, presented two phases for study—the generation of a suitable gas and its proper combustion in the melting furnace. It became evident early in the investigation that efficiency in combustion was largely dependent upon a supply of gas uniform in quality and quantity. In other words, the gas producer was the vital factor in the problem, and in its correct design lay the real secret of successful use of producer gas in glass-making.

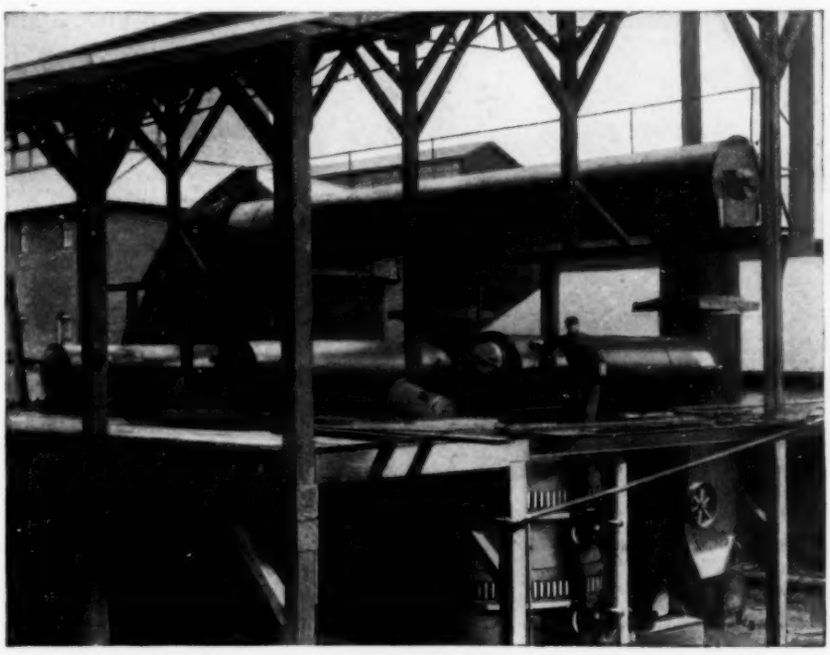
The demand for uniformity was met with their standard 10-ft. furnace-type producer. In this type fuel is fed continuously from a chamber so placed that it lets the fresh coal sink down on to the firebed, as the latter requires it, and in amounts exactly proportional to the needs of that part of the bed passing beneath the chamber at the time the coal is fed. The result is a perfectly leveled firebed at all times. In addition to this automatic leveling, uniformity of texture of the firebed through the body of the producer is obtained by means of a twisting action imparted to the firebed by revolving the upper and lower portions of the producer at different speeds. The function of this twisting effect is to close up incipient blow holes.

This method of feeding and agitation is radically different from the older schemes of intermittent firing, with consequent rush of gas immediately after each dumping of coal. Not only is the supply of gas from the Chapman producer uniform, but the quality is maintained constant.

Another feature which makes for uniformity is the continuous removal of the ash. This is accomplished by a device as ingenious as it is simple. The ash-removing mechanism includes an ash crusher, which grinds up the larger pieces of clinker that may be formed. The operation is entirely automatic, so that once it is set for the percentage of ash in the coal used it needs little attention beyond wheeling away the ejected ash.

Previous attempts to use producer gas for glass-making have met with much annoyance from the large amounts of soot which collected in the flues, and necessitated frequent shutdowns for removal. The Chapman Engineering Company attacked this problem from two points of view—repression and disposal during operation.

In the matter of repression, the small amount of soot is one of the features of the Chapman producer, which results from the unique method of fuel feed. The Chapman Company has originated a method of burning the soot in the flues without opening up the doors of the flues, as in the usual Sunday "burnouts." This is done by means of an air blast introduced at regularly spaced intervals along the line of the flues. To a certain extent this method of soot elimination conserves the heat, otherwise lost, which results from the combustion of this much carbon (in the form of soot).



INSTALLATION OF THREE CHAPMAN GAS PRODUCERS

Pneumatic-Type Recording Tachometer

The field of usefulness of recording tachometers is almost unlimited because there is a great need for measuring and controlling the revolutions of shafting, machinery, engines, etc. In some processes in mills it is desirable to have a certain speed or rate of revolutions maintained continuously or certain stops made periodically, but not too often, and the recording tachometer provides the superintendent or manager with information about the actual operating conditions maintained. For instance, blast-furnace blowing-engines are driven at a certain predetermined number of revolutions per minute, but are usually slowed up once every four hours at casting time.

Bristol's pneumatic-type recording tachometer has been developed to meet such requirements. It is now extensively used in connection with blast-furnace blowing engines for recording the speed of paper machines, etc.

In many instances it is not convenient to have a recording tachometer installed in self-contained form and located near the revolving shaft. One of the special features of the new Bristol pneumatic-type recording tachometer is the flexible connecting tube 25 ft. long or longer between the revolving mechanism and recording instrument which is mounted in any convenient position, as, for instance, on a switchboard or the wall of engine room.

The patent on this pneumatic recording tachometer was issued on July 30, 1912, to Prof. Wm. H. Bristol, and these tachometers, as shown complete in Fig. 1, have now been perfected for use under ordinary shop conditions. Some of the first models of this new tachometer have been in successful service for more than 24 years.

The pneumatic principle of operation depends on the centrifugal action of air in a revolving tube which is connected on the recorder through a special oil seal and flexible connecting tube.

Fig. 2 shows diagrammatically the construction of the revolving mechanism. B designates a hollow circular protecting base and at its upper surface is provided a bearing for a hollow shaft D. This shaft is

arranged to be rotated from any desired mechanism through a set of gears and pulleys (or sprockets).

A pulley C is shown over which a belt runs to a similar pulley attached to the shaft whose revolutions are to be measured and recorded. In practice most of these tachometers are being furnished with special form of sprocket and chain instead of pulley and belts.

FIG. 1.—PNEUMATIC-TYPE RECORDING TACHOMETER

The lower end of the hollow shaft D, terminates in a horizontal tube A, open at its extremities. The upper end of the hollow shaft is surrounded by a casing E. It is partly filled with oil and into this extends the free end of another tube F. The tube F is stationary and is joined at its outer end to a flexible capillary connecting tube G, leading to the recording instrument.

The recorder used with this patented speed measuring device is a special low-range Bristol recording

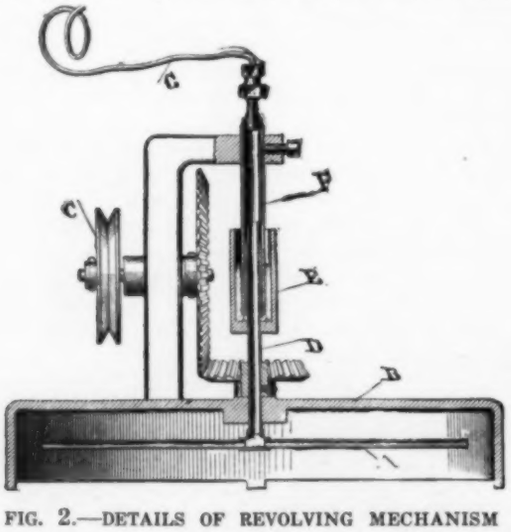


FIG. 2.—DETAILS OF REVOLVING MECHANISM

vacuum gauge. The recording instrument may be installed either near to or at a distance from the shaft or engine, the speed of which is to be recorded, and a suitable length of flexible copper tubing is furnished to connect the recorder with the revolving tube.

These tachometers are manufactured by the Bristol Company of Waterbury, Conn., who also manufacture electrical tachometers.

Chart Recording Instrument

The Brown Instrument Company and the Keystone Electrical Instrument Company, of Philadelphia, Pa., are placing on the market a new continuous recording instrument for use as an electrical pyrometer for recording temperatures, and also as a recording voltmeter or ammeter. The clock mechanism is placed behind the record chart instead of to one side, and the record chart is the only part shown on the face of the instrument.

A two months' roll of record paper is used, which can be supplied with an ink ribbon to make a dotted ink record, or the record can be made on coated paper, which does away with the use of ink or ribbon entirely. It is only necessary to wind the clock once a week and change the roll of record paper once every two months.

Fig. 1 shows the instrument with a 10 hours' record on the recording chart. One scale is placed above the record so that the indications are clearly visible at all times, and the paper has the scale printed on it

FIG. 1.—CHART RECORDING INSTRUMENT

for direct reading. The instrument is shown with the door open so that the interior construction can be seen. This case need only be opened once every two months to renew the roll of paper.

This continuous recording instrument is intended to be used particularly as an electric pyrometer in conjunction with thermo-couples, or with resistance thermometers for measuring low temperatures, or for recording volts or amperes. The d'Arsonval type of direct-current instrument is used, of the frictionless type, to prevent lag in the readings and secure a sensitive and accurate instrument.

The El Ore Mining & Milling Company, of Elkton, Colo., state that weather conditions permitting they will start work on their new 300-ton milling plant about the middle of March, and invite correspondence from mining machinery manufacturers who may wish to take a contract on the building of the plant as a whole, or in part, according to the specifications which the company will be prepared to furnish to manufacturers or contractors.

Electric Steel Melting

Mr. John A. Crowley, president of the John A. Crowley Company, of New York City, recently returned from England, having successfully concluded negotiations abroad for the exclusive representation of the Grönwall electric steel making furnace for this country.

The inventor is perhaps better known in this country in connection with the ore-smelting furnace of the same name which has had such noticeable success in smelting the Swedish ores, but his steel-melting and refining furnace has now been brought to a stage where it is being successfully operated in several of the English mills, and is also being introduced in the Sheffield section.

The Grönwall furnace is well adapted to either melting cold charges or refining from the molten metal as it is a two-phase type arc furnace with a neutral return fixed in the bottom of the furnace under the lining. Each phase of a two-phase circuit being connected to one of the vertical electrodes, which method forms independent arcs, insures a steadier running than if both arcs were in series, and noticeably reduces the instantaneous jump of the current from 50 per cent under load to 100 per cent over load, especially in melting from cold charges, and also produces a vertical as well as horizontal circulation in the metal bath. The neutral return is level with the brickwork at the bottom of the furnace and does not project or weaken the lining of the hearth, nor is the molten metal subject to any reaction on account of this neutral return. The electrical features of this furnace were described in detail and discussed in an article in our issue of November, 1911 (Vol. IX, p. 573).

The furnace is of the tilting type, permitting the withdrawing of the slag at any stage of the refining process and the introduction of another slag, and also permits the withdrawing of any part or all of the charge at any time.

The John A. Crowley Company will install one of these furnaces as soon as a suitable location can be secured. They will first aim at the production of higher grades of alloy steels for commercial purposes, but the production will not be entirely limited to this class of material, but will include the high-carbon tool and spring steels. Considerable attention will also be given to producing a high-grade steel for castings, for which line of work the furnace is particularly adapted.

The Non-Ferrous Metal Market

The metal markets for copper, tin, lead and spelter have been without particular feature, and only slight changes have taken place in prices. Fluctuations in price have followed closely the changes in demand and while the tendency has been upward the higher prices have not always held in the face of lessened demand. Producers have been willing to make concessions and buyers have not taken more than enough to meet immediate needs.

Copper.—While the export market has been good the domestic demand has been variable. European stocks continue to decline in the face of heavy exports from this country. Local demand is considered to be improving slowly but steadily. Electrolytic copper is quoted at 14.60@14.70, and Lake at 14⅞@15⅛ cents.

Tin.—The tendency of prices in this market has been upward, and domestic demand has improved. A slight premium has obtained for immediate delivery.

Lead.—The American Smelting & Refining Co. raised its New York price to 4.15 cents on February 11, but reduced it again when the demand slackened. St. Louis lead prices have been above the New York parity. At last available reports the market has slumped decidedly, and New York lead is offered at 4 cents, with St. Louis at 3.90@3.92½ cents.

Spelter.—This market has been quiet, with a fair demand for metal. The tendency of prices is upward, New York spelter being quoted at 5.40@5.45 cents, and St. Louis at 5.25@5.30 cents.

Other Metals.—Business in aluminum has improved, but is still quiet. New York quotations are 18¾@19 cents per pound. Prices for antimony are firm and various brands are quoted at from 6 to 7.35 cents. Improvement also is noted in the quicksilver market, New York price being $39 per flask of 75 lb. San Francisco quotes $38.50 per flask.

Personal

Dr. F. G. Cottrell, of the Bureau of Mines, has been engaged in the installation of apparatus for fume recovery at Anaconda.

Dr. **Rudolf Gahl** is making metallurgical investigations for the Inspiration Copper Company in Arizona.

Mr. **Ulysses A. Garred** has resigned his position at the Washoe smelter, Anaconda, Mont., and will go to Queensland where he will be with the Mount Morgan Gold Mining Co. He will be succeeded at Anaconda by **Mr. W. N. Tanner.**

Mr. H. A. Guess, formerly manager for the Federal Lead Co., Flat River, Mo., has been appointed consulting engineer for the American Smelting & Refining Co., with headquarters at 165 Broadway, New York City.

Mr. H. W. Hardinge, president of the Hardinge Conical Mill Company, has left New York for a six week's trip through Western mining centers.

Mr. H. C. Hoover, and his wife, **Lou Henry Hoover,** will be guests of honor at a dinner of the Mining & Metallurgical Society of America in New York City on March 9, at which time they will be presented with the Society's medal for their "Distinguished Contributions to the Literature of Mining."

Mr. William F. Jahn has been engaged as superintendent of the new cyanide mill of the New York & Honduras Rosario Mining Co., at San Juancito, Honduras, C. A.

Mr. J. George Lehman, vice-president and general manager of the Bethlehem Foundry & Machine Co., South Bethlehem, Pa., has just returned from a business trip abroad. Mr. Lehman spent some time in England and Continental Europe on matters pertaining to the development of acid-resisting iron, and while abroad closed a contract with the Lennox Foundry, of London, for the exclusive selling rights for Tantiron in the United States and Mexico. This acid-resisting metal has been in very successful use throughout Europe for a number of years.

Messrs. **Dorsey A. Lyon** and **Robert M. Keeney,** who have been stationed at the Pittsburgh laboratory of the Bureau of Mines, have been sent to Salt Lake City to start the cooperative federal-state work at the School of Mines of the University of Utah.

Mr. Richard S. McCaffery has been appointed professor of metallurgy in the University of Wisconsin. For the past few years he has held the position of professor of mining and metallurgy in the University of Idaho.

Mr. **H. P. MacGregor** has opened a laboratory for industrial and engineering chemistry at 535 First National Bank Building, in Denver, having recently severed his connection with Mariner & Hoskins, Chicago.

Mr. **Richard K. Meade,** Mechanical and Industrial Engineer, 202 North Calvert Street, Baltimore, Md., has just completed plans for a new coal pulverizing plant for the Pennsylvania Salt Manufacturing Co. This plant is designed to furnish coal for heating nodulizing furnaces. The plans call for a building of steel, 30 x 90 ft., and all the stairs, runways and galleries are to be of steel. No wood is to be used whatever in its construction. The equipment will consist of a dryer and two pulverizers, together with scales for weighing the coal, elevators, conveyors, etc. All the machinery will be motor-driven.

Dr. **Richard Moldenke** has resigned his position as secretary of the American Foundrymen's Association, but will continue to give his advice and assistance in editing the "Proceedings" of the Association.

Mr. **Richard A. Parker** has been elected president of the Colorado Scientific Society for the current year. Other officers elected were **E. N. Hawkins** and **T. B. Stearns,** vice-presidents; **John W. Richards,** treasurer; **H. C. Parmelee,** secretary; **J. D. Skinner, Charles A. Chase** and **Victor G. Hills,** members of the executive committee.

Mr. **George C. Piwonka** has resigned his position as general sales agent for the Western Chemical Manufacturing Co., Denver, Colo., and will engage in business in Cleveland, Ohio.

Mr. **B. Stanley Revett** is resident general manager of the consolidated dredging properties at Breckenridge, Colo., recently acquired by the Tonopah Mining Co. Mr. Revett was formerly manager for one of the companies that sold to the Tonopah concern.

Mr. **Carl J. Trauerman,** of the metallurgical firm of Rothwell & Trauerman, Butte, Mont., will take charge of the milling operations of the Bully Boy Co., Marysvale, Utah, after March 1.

Mr. **Guy M. Vail,** mining and metallurgical engineer of Portland, Ore., was in Denver recently on professional business.

Mr. **Archer E. Wheeler** has resigned his position as superintendent of the Boston & Montana Reduction Works of the Anaconda Copper Mining Co., to accept a position as consulting engineer to Union Minière de Haut Katanga, which has mining interests in Africa. Mr. **John H. Klepinger,** formerly assistant superintendent, succeeds Mr. Wheeler, and Mr. **Milo W. Krejci,** metallurgist for the company, has been named to succeed Mr. Klepinger.

Mr. **James Wood** has resigned his position as superintendent of the Calumet & Arizona smelter, and will no longer engage in active work.

The sulphur output of Sicily has shown a steady decrease during the past two working years, according to a recent Consular report. From August 1, 1912, to July 31, 1913, the total production was 351,752 tons, a decline of 15,489 tons, as compared with the previous year. The most striking decline in the exports is that to France, which has always been the best customer. This decline is believed to be due to the establishment of large sulphur refineries in France by the Union Sulphur Co. The Sicilian Sulphur Combine expresses the hope that the steady increase in consumption will permit the Sicilian industry to continue.

Digest of Electrochemical U. S. Patents

PRIOR TO 1903.

Arranged according to subject-matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

REFINING METALS *(Concluded)*

669,442, March 5, 1901, Hans A. Frasch, of Hamilton, Canada.

Relates to the extraction of metals from metalliferous substances such as mattes, slags, ores, etc. The metalliferous material is suitably crushed and placed on the bottom of a tank where it is electrically connected as anode. Above this is placed a layer of sand as a diaphragm. An alkaline salt, such as sodium chlorid of 20° Baume strength is the electrolyte. Above the diaphragm are a plurality of cathodes. A plurality of tanks are connected so that the electrolyte flows from one to another in series. In the first and last tank, an overflow is provided from the anode compartment, and a separate overflow from the cathode compartment. In the intermediate tanks but one overflow, from the cathode compartment, is provided. The salt solution is supplied to the first tank and electrolysed, the overflow from the anode compartment passing to the intermediate tanks. In the cathode compartment of the first tank sodium hydroxid is formed, which is removed. In the intermediate and last tanks, copper is deposited from the circulating electrolyte. After leaving the last tank the electrolyte has been freed from copper, and of the remaining metals, iron is precipitated chemically, and the nickel, cobalt, etc., separated electrolytically.

679,824, August 6, 1901, Anson G. Betts, of Lansingburg, New York.

Relates to the electrolytic refining of crude lead, or "work-lead" containing such substances as gold, silver, copper, antimony, arsenic, sulphur, bismuth, nickel, iron, zinc and tin. This alloy is cast into an anode and electrolysed in a solution of about fifteen per cent lead fluosilicate and fluosilicic acid, together amounting to about twenty-five per cent of the solution. Such an electrolyte has a resistance of about two and two-tenths ohms per cubic inch. During electrolysis the electrolyte is circulated and the deposited lead is mechanically compressed from time to time, to break down sprouts and to present an even surface. When a sufficiently thick deposit is obtained, it is removed and melted. The cathode is preferably a sheet steel plate coated with lead.

684,049, October 8, 1901, Elmer G. Elliott and Valentine Kishner, of Perth Amboy, New Jersey.

Relates to apparatus used in refining metals. In practice the anode plates often come from the casting furnaces more or less distorted; also during operation some of the plates will bend or buckle. This invention consists in providing each tank with one or more series of insulating-pins which are mounted upon a movable support and connected to suitable manual operating devices. The pins are interposed between the plates where needed to mechanically separate them. The pins may vary in length and in location in the tanks.

687,800, December 3, 1901, Arthur L. Walker, of Perth Amboy, New Jersey.

Relates to a plant for electro-refining, and is an improvement in the conductors used to carry the current. It consists in placing a conductor plate or strip between two tanks, so that the cathodes of one tank and the anodes of the next are electrically connected. By this means the investment in conductors to carry the current from tank to tank is reduced at least eighty-three per cent over the former practice.

694,699, March 4, 1902, T. Ulke, of Sault Ste. Marie.

Relates to the refining of composite metals such as nickeliferous-copper material. In practice it is advantageous to use a material containing not less than twenty per cent nickel and eighty per cent copper, using a circulating electrolyte of sulphate of copper and nickel. During electrolysis, a certain amount of electrolyte is regularly withdrawn and replaced by copper sulphate solution. The copper deposit is by this means obtained under substantially uniform conditions. To the withdrawn solution is now added either ammonia or ammonium sulphate, thereby precipitating the nickel as nickel-ammonium sulphate crystals which may be purified by further crystallization. The nickel salts are then separately dissolved, the solution made alkaline with ammonia, and electrolysed. From time to time a portion of the impoverished electrolyte is withdrawn and used to precipitate the nickel crystals from the copper solution.

687,831, April 15, 1902, Hans A. Frasch, of Hamilton, Canada.

Relates to refining mattes, etc., and electrodepositing nickel. Refers to his prior patents 669,441 and 669,899. The apparatus preferably used is a series of tanks the bottom of which is covered with broken matte, etc., above which is placed a layer of sand to act as a diaphragm. A solution of sodium chlorid, 20° Baume, is added to the tanks until it comes through the sand diaphragm. Each tank has double inlet and outlet tubes, one of each below the diaphragm for the circulation of the anolyte, and one of each in the upper part above the diaphragm for the circulation of the catholyte. As catholyte, an ammoniacal solution of a nickel salt is used. The two solutions are circulated either continuously or intermittently. Nickel is deposited on the cathode, while the anolyte dissolves the metals in the matte, etc., as chlorides. The solutions do not mix with each other, the heavy chloride always remaining below the diaphragm.

713,277, November 11, 1902, Anson G. Betts, of Lansingburg, New York.

This patent was subsequently reissued as "Reissue 12,301." It relates to an improvement in the electrodeposition of lead by the process described in his earlier patent 679,824. The improvement consists in the addition of a reducing agent, such as gelatin, pyrogallol, resorcinol, saligenin, ortho-amido-phenol, hydroquinone, and sulphurous acid. Phenols of the aromatic series are well adapted for use in this process. It is preferred to use gelatin in the proportion of one part to about five thousand of solution. By the process the mechanical treatment of the lead described in the earlier patent is avoided, the deposited lead being compact and having a specific gravity of about 11.36. A current strength of ten to twenty amperes per square foot of cathode surface, and a corresponding E. M. F. of 0.15 to 0.35 volts for each element is used. With higher currents the lead becomes harder and more brittle.

713,278, November 11, 1902, Anson Gardner Betts, of Lansingburg, New York.

This patent was subsequently reissued as "Reissue 12,117." It relates to the refining of lead and refers to his prior patent No. 679,824. This patent has substantially the same subject-matter as the patent 713,277, but claims the product produced by the process claimed in 713,277.

714,861, December 2, 1902, David H. Browne, of Cleveland, Ohio, Assignor to The Canadian Copper Company, of Cleveland, Ohio, a Corporation of Ohio.

Relates to refining copper-nickel alloys. The material is cast into anodes, and part also into fragments; the latter put into a shot tower and treated with a current of chlorin gas and a shower of sodium chlorid. The fragments are dissolved, forming a solution of cuprous and nickel chlorids. This solution is passed through an electrolytic cell in which the copper is entirely removed, using the copper-nickel anodes and sheet metal cathodes. The outflowing nickel chlorid is treated with an alkali to precipitate the iron, leaving the nickel chlorid pure. This solution is now electrolysed, the chlorin evolved at the anode being used to treat the copper nickel fragments in the shot tower.

The nickel deposited upon the cathode is substantially pure.

Book Reviews

Chloride of Lime in Sanitation. By **Albert H. Hooker,** Technical Director of the Hooker Electrochemical Company. Octavo (14½ x 22½ cm.), 231 pages; price $3.00. New York: John Wiley & Sons. London: Chapman & Hall, Limited.

The author acknowledges that Dr. L. H. Baekeland advised and inspired the writing of this work, which may be considered as a means of propaganda for sanitation in general and for the makers of bleaching powder in particular. Seven chapters describe respectively the manufacture and properties of the material in question, its uses for water purification, disinfection of sewage, street sprinkling and flushing, general sanitation (including use in epidemics), farm purposes, and killing the house fly. These occupy about one-third of the book, the other two-thirds being a compilation of abstracts and references on all of the above topics, either reproduced as a whole or carefully condensed. Mr. Hooker and his staff have made a timely and carefully-written contribution to an important branch of medical chemistry.

* * *

Laboratory Experiments in General Chemistry. By **H. B. North,** D.Sc., Associate Professor of Chemistry in Rutgers College. 12mo. (19 x 12½ cm.), 205 pages, 36 illustrations. Price, $1.00 net. New York: D. Van Nostrand Company.

This book describes 500 experiments, to be performed in connection with seeing a series of experimental chemical lectures, and using a good text book. From these, selections can be made suitable for varying classes of students. The experiments are excellently chosen, very clearly stated, necessary precautions to avoid danger given in italics, and attention called to the observations and conclusions in a manner calculated to sharpen the wits and educate the reasoning powers of the student.

The table of melting points of the elements needs up-to-date revision. The use of the atomic weights as whole numbers is to be commended in a work of this kind, as it avoids giving the student a fictitious idea of the quantitative accuracy of his experiments.

* * *

Industrial Chemistry. Edited by **Allen Rogers** and **Alfred B. Aubert,** in collaboration with thirty-four specialists. Large octavo 16 x 24 cm.), xiv + 854 pages, 340 illustrations. Price $5.00 net. New York: D. Van Nostrand Company.

The volume is intended to represent American methods and processes, being an assemblage of the ideas of recognized authorities in their respective fields. Minor details have been given lesser attention. Theoretical considerations have been introduced only where necessary, but the subject matter is essentially descriptive, with most emphasis on the fundamental principles of the methods employed.

The contents embrace general processes, materials of construction, water supply, fuel, producer gas, boilers, engines, motors, power transmission, the common acids,

commercial chemicals, chlorine industries, electrochemical industries (by W. S. Landis), lime, cement, plaster, clay, bricks, pottery, glass, white lead, pigments, oils, paints, iron and steel (by Bradley Stoughton), fertilizers, illuminating gas, coal tar and its products, the petroleum industry, distillation of wood, oils, fats, waxes, soaps, glycerine, candles, laundering, essential oils and perfumes, resins and gums, varnish, sugar, starch, glucose, dextrine, brewing and malting, wine, distilled liquors, textiles, dyes, paper, explosives, leather tanning, glue, gelatin, casein.

The treatment is very unequal; no chapters can be said to be poorly written, but some are much better than others—as was perhaps to be expected. Some important industrial chemicals are entirely omitted; hence the reason for cataloguing above the contents of the book. Such omissions are non-ferrous metals, refractory materials, celluloid, bakelite, enameling, treatment of sewage.

The book is beautifully printed and contains some very well written articles; it can be of great use to the student or manufacturer wishing to familiarize himself with the elements of industrial chemistry.

* * *

The Electric Furnace: Its Construction, Operation and Uses. By **Alfred Stansfield, D.Sc.,** Professor of Metallurgy in McGill University. Second Edition. Octavo (14 x 23 cm.), 415 pages, 155 illustrations; price $4.00 net. New York and London: McGraw-Hill Book Company, Inc.

Prof. Stansfield's second edition, revised, enlarged and reset, is practically a new book, and is, at the present moment, the best book in English on the electric furnace. It is very fittingly dedicated to Dr. Eugene Haanel, director of the Canadian Bureau of Mines, who has done so much towards starting electric smelting processes.

The details are carefully and systematically worked out. Particular mention should be made of the five chapters on zinc and on principles of construction and operation. The latter makes use of the recently published data concerning heat conductance of furnace walls and electrodes, and is admirably written. In fact, there is scarcely a chapter in the book which does not deserve commendation.

One disappointment is the bare mention of the "large number" of electric furnaces which have been devised for the manufacture of glass, without any description whatever of these interesting furnaces. Bronn, in *Die elektrische Oefen*, gives a large part of his work to them. The book is suitable alike for students, technologists and the general scientific reader. We congratulate the author on the very useful result of his scholarly and conscientious work.

* * *

Quantitative Analysis by Electrolysis. By **A. Classen,** with the cooperation of **H. Cloeren.** Translated from the fifth German edition by **Wm. T. Hall,** Assistant Professor, Massachusetts Institute of Technology. Octavo (14 x 22½ cm.), xiv + 308 pages, 51 figures, 2 plates; price $2.50 net. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Ltd.

The present edition may be regarded as practically a new book, since it contains all the improvements in the theory and practice of electro-analysis made in the last decade. The translator has added to the original the Spear and Strahan rapid method of determining zinc. He also uses the notation and symbols recommended by a committee of the American Chemical Society. The skilled electro-analyst will find collected here all the reliable information extant, while the general reader will be astonished at the versatility and applicability of electro-analytical methods. Further yet, the electro-chemist interested in electro-plating, electro-extraction or electro-refining of metals will find therein many items of exact and useful information directly applicable to the problems which he is trying to solve.

* * *

Electrical Engineering for Mechanical and Mining Engineers. By **H. J. S. Heather,** B.A. Octavo 13 x 21 cm.), ix + 332 pages, 184 illustrations; price, $3.50 net (9/6d). New York: D. Van Nostrand Company. London: "The Electrician" Printing and Publishing Company, Ltd.

This book contains a series of twenty lectures prepared for and delivered to the resident mechanical engineers of the mines of the Witwaterswand, South Africa. The author was at that time connected with the University of the Cape of Good Hope and the South African School of Mines and Technology.

No attempt was made to impart a general knowledge of electrical engineering, but the lectures were intended to give to the mechanical engineers at the mines the elements of electrotechnics, so that they would be able to understand or possibly to supervise the work of the mine electrician. Any non-electrical engineer wishing to get an intelligent idea of the principles of electrotechnics and of the elements of electrical engineering will find this book helpful and useful.

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Die Quantitativen Untersuchungsmethoden des Molybdans, Vanadiums und Wolframs. By Dr. **Hans Mennicke,** Ing. Chem. Six by 10 inches (18 x 25½ cm.), 231 pages. Price, paper, Mk. 8; bound, Mk. 9.50. Berlin: M. Krayn.

Under this title appears a collection of practically all the analytical work along these lines. The methods of analysis are set forth in the order of their importance, based on the accuracy of the results obtained therewith, and on their commercial applicability.

The subject is treated under four heads: (A) introductory; (B) Molybdenum; (C) Vanadium; and (D) Tungsten. The introductory part describes the determination of carbon and sulphur in metals, ferro-alloys, and special steels containing these rare metals. An appendix gives the literature and a factor table.

The three main subjects are treated accurately and satisfactorily. They are properly subdivided, and special stress is put on indicating the work of greatest value for accurate determinations. The methods of analysis of importance are clearly described in detail and one feels that among them may be found methods applicable to any special cases occurring in the analytical, chemical and metallurgical field of these rare metals.

The book is of value as a guide not only to the student interested in the chemistry of the rare metals, but also to the practical man handling the raw or finished products containing molybdenum, vanadium, or tungsten as a constituent, such as ores, salts and preparations, alloys and steels. As the literature on the rare metals is somewhat scattered, this collective work on the subject treated is probably better than anything in print in the English language.

Suit for dissolution of the American Smelting & Refining Co., under the Sherman act, is being considered by the Department of Justice.

The **Richmond Forgings Corporation,** of Richmond, Va., makers of drop forgings, has opened an office at Detroit, Mich., which for the present will be in charge of Sales Manager Landon C. Wellford, in the Dime Bank Building. Mr. A. O. Knudsen, of Newton Centre, Boston, Mass., will represent the same company in the New England States.